METAL PROGRESS

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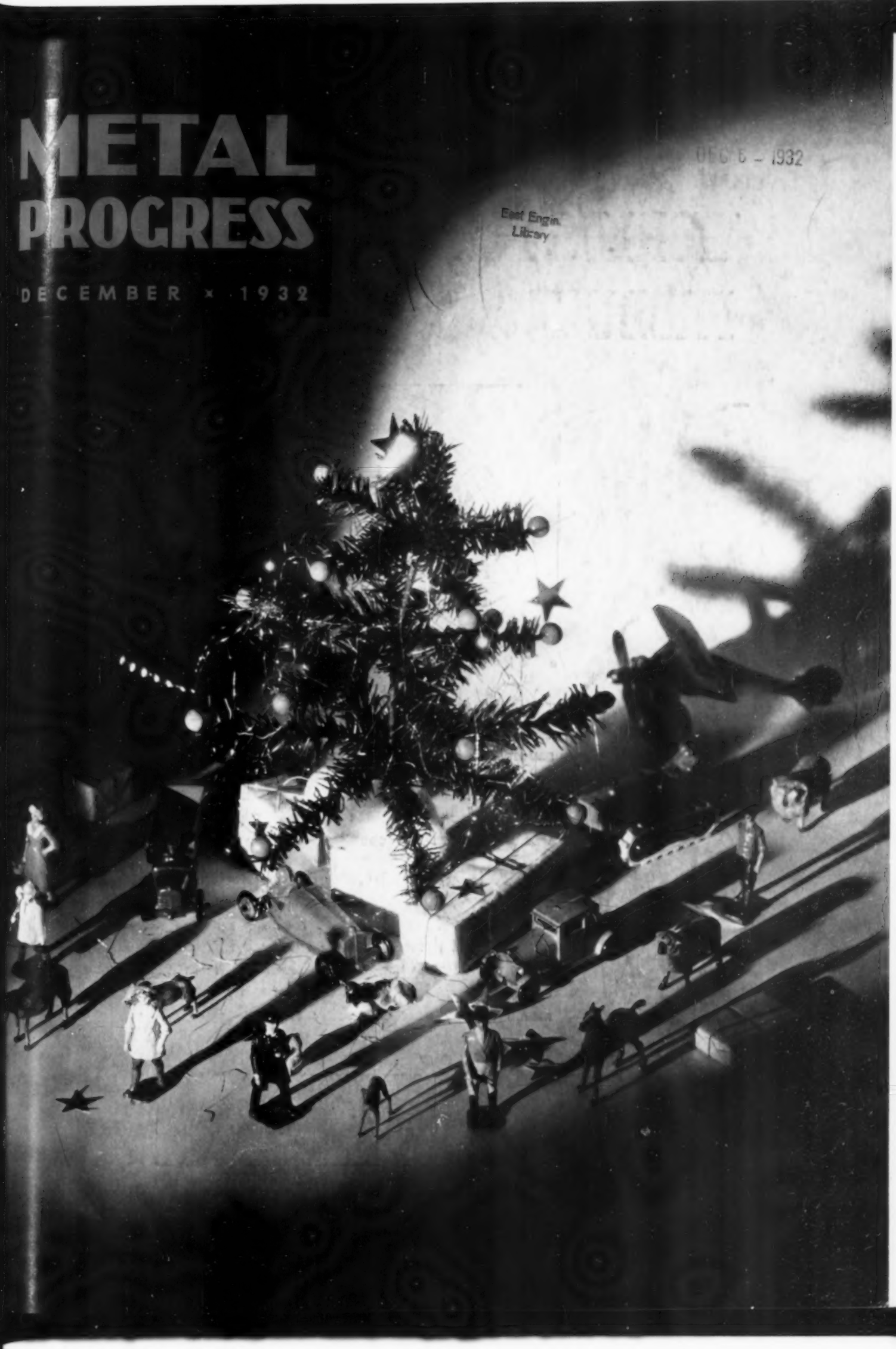

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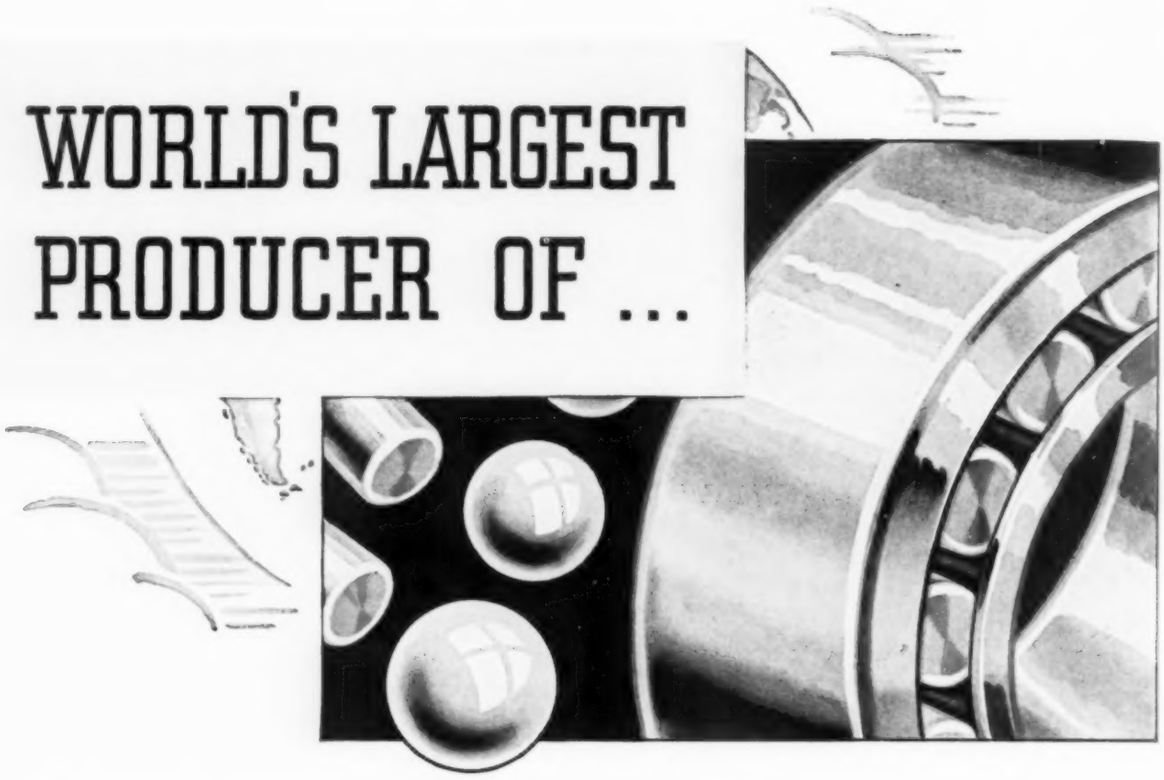

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Metal Progress

American Society for Steel Treating

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. . . American Society for Steel Treating is not responsible for statements or opinions printed in this publication. Editorials are written by the editor and represent his views. He is also sponsor for unsigned and staff articles.

Ernest E. Thum, Editor

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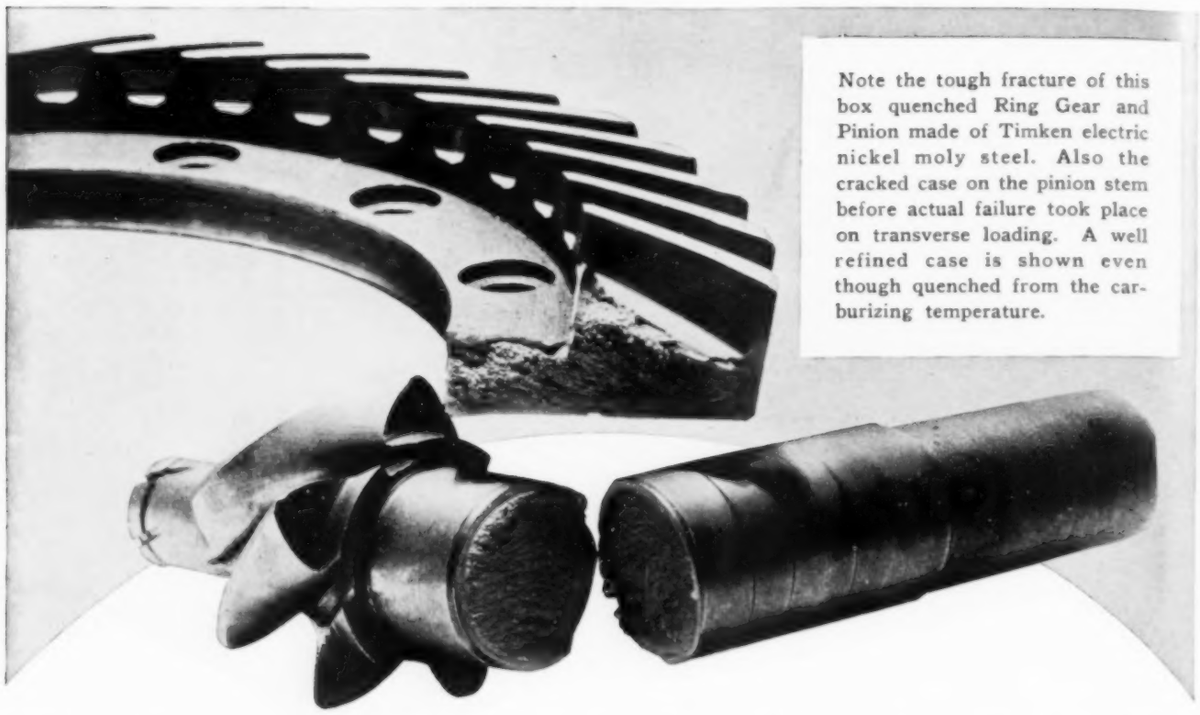

Note the tough fracture of this box quenched Ring Gear and Pinion made of Timken electric nickel moly steel. Also the cracked case on the pinion stem before actual failure took place on transverse loading. A well refined case is shown even though quenched from the carburizing temperature.

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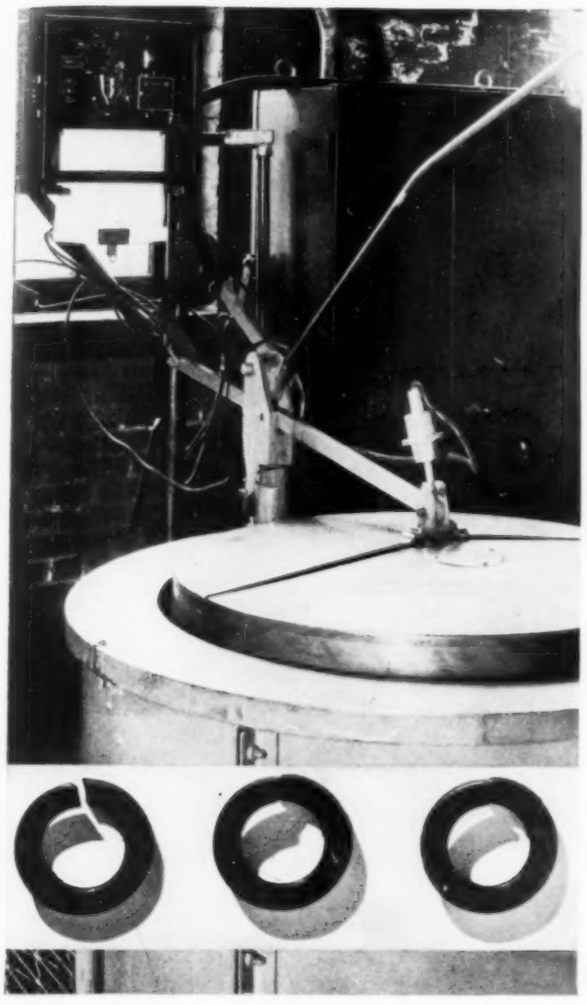

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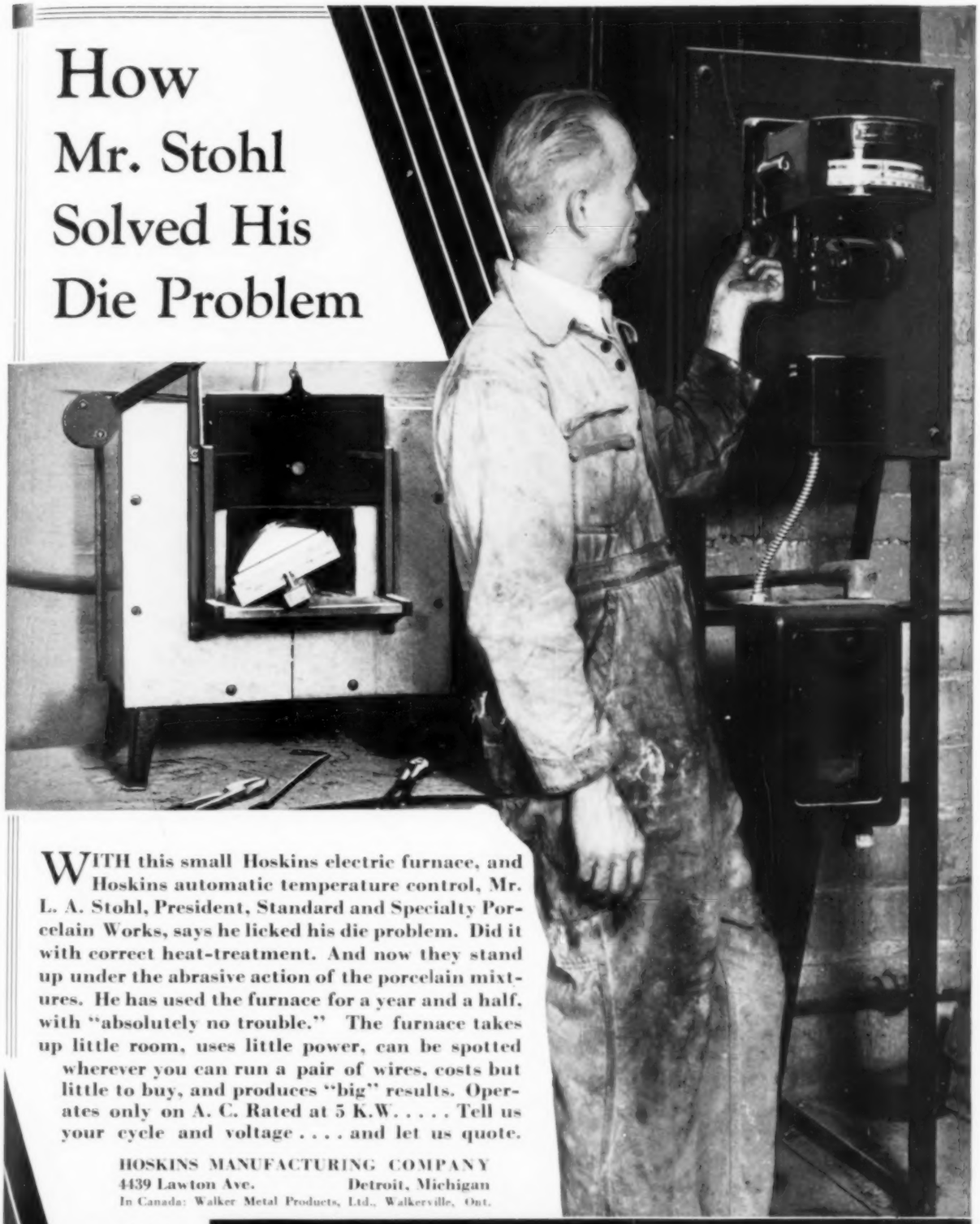
An *editorial background and setting unique among technical publications for its distinctive format and illustrative handling. The book is read, rather than filed for future reference.*

An editorial appeal strictly maintained by the editorial policy reflected in this summary of the last 12 issues: : : : : : : : : : :

Timely articles and discussions	548 pages
Reprinted or copied manuscripts	none
Informative summaries of current publications	52 pages
Financial news, economics, markets	none
Publicity puffs for persons and things	none
Total	600 pages

How Mr. Stohl Solved His Die Problem



WITH this small Hoskins electric furnace, and Hoskins automatic temperature control, Mr. L. A. Stohl, President, Standard and Specialty Porcelain Works, says he licked his die problem. Did it with correct heat-treatment. And now they stand up under the abrasive action of the porcelain mixtures. He has used the furnace for a year and a half, with "absolutely no trouble." The furnace takes up little room, uses little power, can be spotted wherever you can run a pair of wires, costs but little to buy, and produces "big" results. Operates only on A. C. Rated at 5 K.W. . . . . Tell us your cycle and voltage . . . . and let us quote.

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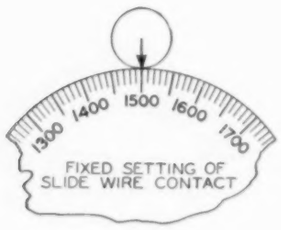

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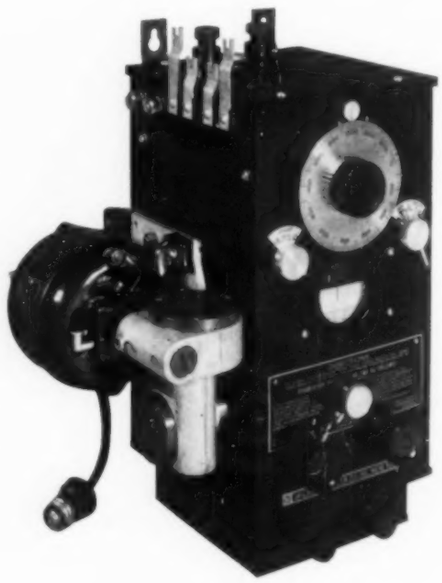

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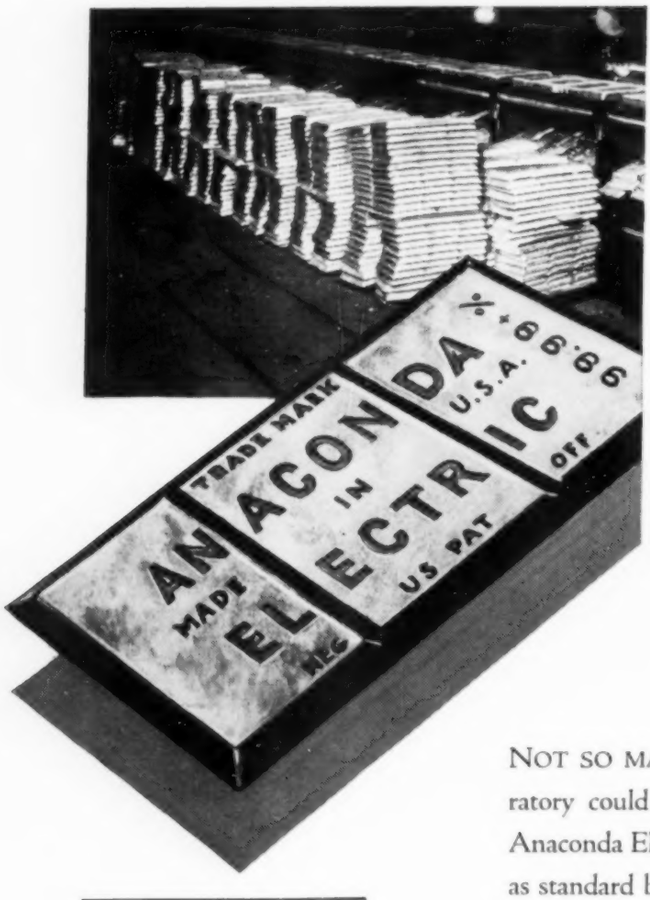

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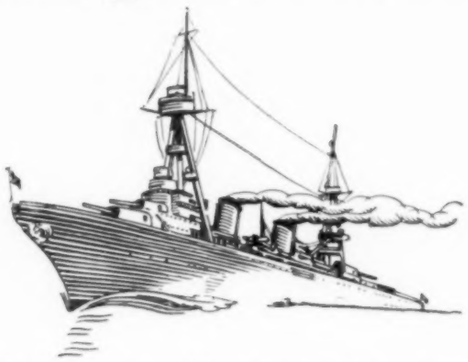

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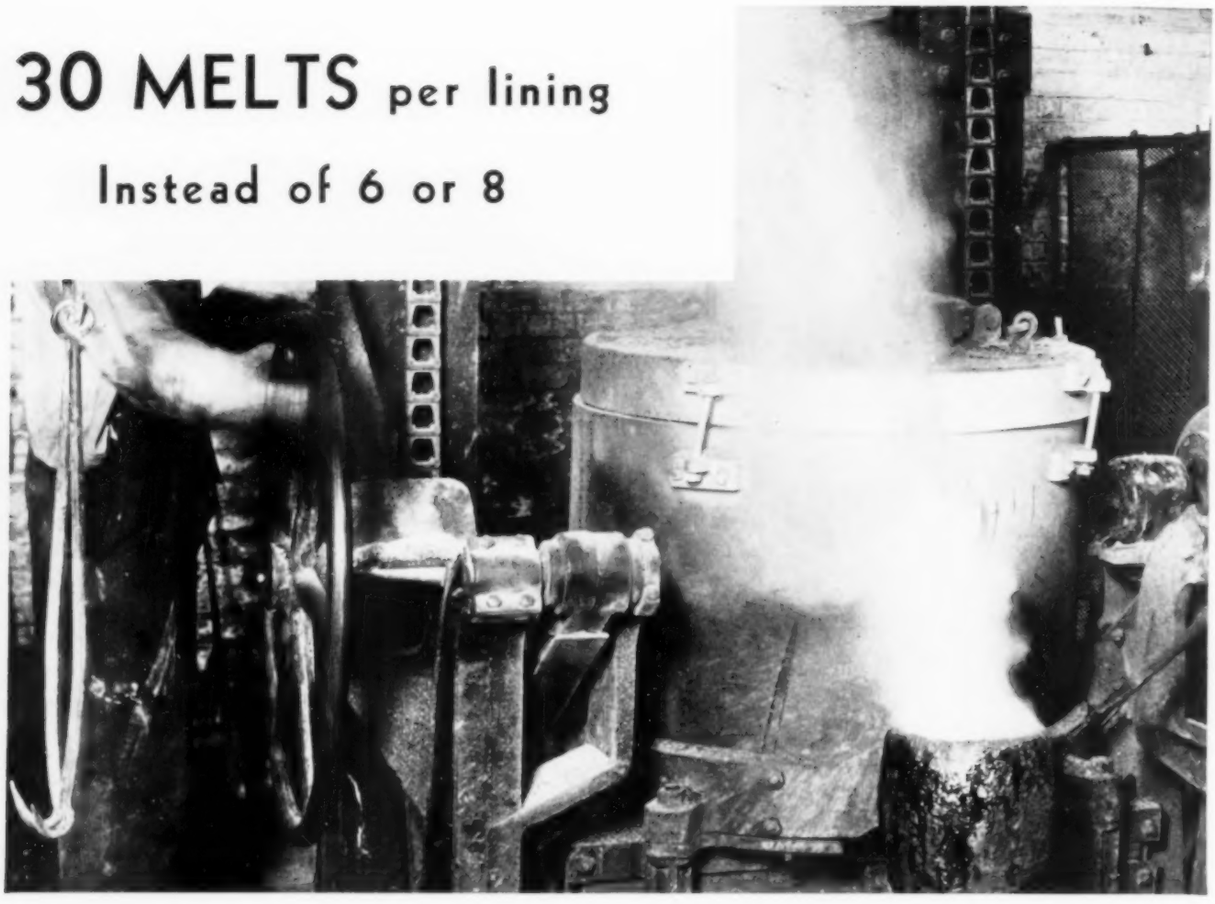

ACTUAL performance in the field is the best proof of the ability of Norton Magnesia Cements to render exceptional service. The following quotation is from a letter recently received:

> ''Relative to the results we have had in making linings for our small induction furnace from your RM 1118 Magnesia Cement, we can state that we have had so much success with it that an order for further material is going out in a few days.
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> ''With the crucibles that we were using we seldom got more than six or eight melts per crucible. We have obtained more than thirty melts with a lining of your material and it is by no means done yet.''

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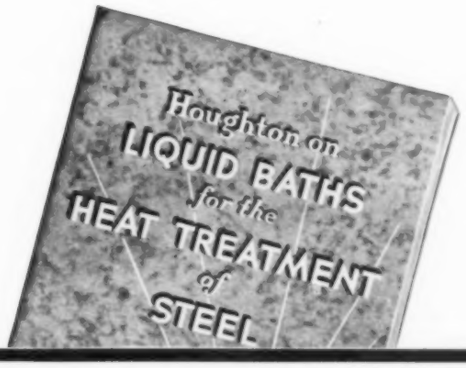

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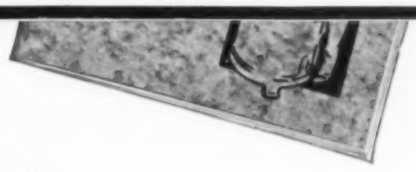

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May this Christmas be for you one of glory and gladness! May true happiness come to those most dear to you! May the incoming year greet you with prosperity in abundance! May every dawn bring with it some new delight for you! May every morning add to your joys, and every evening bring you peace and contentment!

General Alloys Company

Christmas 1932

RHYMINISCENT

As I pause from press of business to pen this idle rhyme,
I'm taking inventory, for it's inventory time.

But it's not the stock I'm checking, nor dollars lost or won,
That concern me in accounting when final statements done.

I am thinking of the "life" I've spent, the things I've done and said,
The things I cannot figure in the black or in the red.

I am thinking of the men I've met in plants throughout the land,
Who've given of their time to me, held out a friendly hand.

Who placed a certain confidence in statements that I made,
And staked their judgment on my claims and on the game I played.

I am thinking of the fellows who have gone out of their way
To help me put my stuff across . . . they do it every day.

I see friendships that are ripening, that have stood the test of years,
Have I kept faith with those who trusted, or am I in arrears?

What are dollars, few or many, to record commercial strife
When checked against the finer things along the path of life?

In intercourse with fellow men, the give and take of trade,
The profit of enduring worth is not the dollar made.

I am humble as I contemplate how little I can say or do
To show that I appreciate what Men, one may be you,
Have done to aid me on my way.

Reprinted by request from Metal Progress, December, 1930

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YOU are getting your CYANEGG* and CYANIDE MIXTURES on the basis of Sodium Cyanide content. Each container carries an *identifying* label giving the amount of Sodium Cyanide present. This R & H label is positive assurance of true strength and reliability—your guarantee that you are getting what you pay for.

You are getting MORE than a product when you buy R & H CYANIDES. You are getting the extra advantage of our many years of experience in the efficient adaptation of Cyanides to specific heat treating problems. This is a service available to you also, at no added cost—when you buy R & H CYANIDES.

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EASILY LEARNED

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AN EDITORIAL entitled "Information Wanted About File Testing" appeared in the September issue of METAL PROGRESS. Since we have given this subject considerable attention during the past 10 years, we will contribute the following to the discussion.

The article mentioned starts with the observation that the notable recent progress in the determination of metallurgical hardness has been a refinement in the equipment for measuring indentation hardness, and that no corresponding advances have been made in testing for the variety of hardness which resists abrasion, namely, "scratchardness." It goes on to state:

> "In fact we still rely upon a file to determine scratchardness. It is the quickest, easiest performed, and most reliable test for high hardness on large surfaces. Even though it is of little use in a precise specification, it is still extremely valuable for routine inspection, especially of quenched articles before tempering, and especially if the condition of the file after the test is also observed.
>
> "There must be some grounds for the widespread belief that scratchardness is closely related to ability to resist wear and abrasion, for the testing file is used by makers of metal cutting tools, roller bearings and gears, and we frequently hear the statement that the more the surplus over filehard, the better the article will stand up in service. If the file test had received the same attention that has been bestowed upon indentation hardness of 'dentability,' we would now be able to discriminate between various grades of super-scratchard surfaces."

It *is* a fact that the file is still relied on to determine the hardness of a large variety of cutting tools and of heat treated machine parts. We have found that, in the hands of a skillful workman, a properly treated file becomes a reliable measurer of hardness which can be used to pass or reject high quality metal products, hardened or tempered. A file will bite into the metal in exact proportion to its degree of hardness or softness.

There is also some foundation for the wide-

spread belief that scratchhardness is related to the ability to resist wear and abrasion. When the file takes hold of the metal it penetrates it to a small degree, as well as abrades, scrapes, or wears away a portion of the surface. That is the meaning of the term "abrasion." When a cutting tool grows dull, it does so by wearing or abrading action on the sharp edge. Practically the same thing happens when gears and roller bearings wear; that is, some of the edge or surface is removed by an action similar to the action of the file — not as drastic, to be sure, but nevertheless it is the same in principle. This being true, it can readily be seen that, if the degree of action of the file on the surface can be measured, then a measure of the ability of the tool or the metal to withstand wear will be possible.

Of course, this can only be true within certain limits, because the statement in the article that "the more the surplus over file hard the better the article will stand up in service" is not true of all cutting tools. It may be and probably is true of articles which get a sliding or rubbing action, but for cutting tools there is a degree of hardness, below file hard, that is best for the particular tool and material being used, and this degree of hardness varies with the type of tool used and with the material from which the tool is made. "Tough hardness" gives the best results in resisting abrasion. Hardness that is surplus over file hard is very apt to be a brittle hardness.

Contrary to the next thought implied in the article, the file test has received a great deal of attention. The problem of being "able to discriminate between various grades of super scratchard surfaces," scientifically, without the necessity of the workman's skill, is a big problem, and one not easy to solve. It should be remembered that even the use of other hardness testing machines requires a certain amount of skill on the part of the operator.

There is no table of hardness numbers for the file test, except that it is possible to know the hardness of a piece of carbon tool steel the file will cut before it is used for testing. This statement leads into the next paragraph of the editorial, which begins a series of questions about the method of making the file test and its limitations:

> "First, about the files: Doubtless the test depends upon the fineness of the teeth, their sharpness, shape and hardness. Must we depend upon the makers' guarantee that the files are 'standard and uniform' (whatever those two words may mean) or is there any means whereby the user can determine this for himself? If he uses a test block, how should this be prepared, hardened and tested to make sure it, itself, is 'standard and uniform'? How dull can a file become before it is useless — that is, how many tests can a single spot make?"

Up to the present time it has been, and is now, necessary to depend on the skill of the workman. He acquires skill in judging the hardness of the article by the cutting ability of the file on the piece being tested, learning also to what degree the file must cut or not cut to judge the piece too soft or too hard. This skill is not difficult to acquire and there are many men in production work who test the hardness of tempered steel articles with a file, and the result gives greater satisfaction than can be had by any of the hardness testing machines now on the market.

Of course, the file gets dull, but good judgment on the part of the workman overcomes this difficulty. Pieces of steel or samples of the product known to have the proper hardness and temper can be used as gages or master test pieces for the beginner, and later for comparison tests when any doubt exists as to the hardness of the article or as to the cutting ability of the file.

As long as the file will cut the master test piece, it is good to use for testing purposes. The number of times a "single spot" on the file can be used will depend upon the hardness of the articles being tested and the degree of skill acquired by the workman, but there is always the master test piece to prove the accuracy and cutting ability of the "single spot."

It should be remembered that files made for hardness testing are not suitable for removal of stock. Just as soon as the file bites, or does not bite, the file should be removed from the work, in order to preserve and prolong its biting quality. It is obvious that the file test is limited to articles undamaged by a slight scratch before final finishing.

It is not necessary to depend upon the maker's guarantee that the files are standard

and uniform. The term "standard," when applied to testing-files, means that the files are made to cut a standard of hardness. That is, the files will cut a piece of a given size of high carbon steel which has been specially heat treated and this treatment is carefully duplicated each time a test piece is made. The term "uniform" means that each and every testing file made to the standard will cut the standard. Any reputable file manufacturer who makes testing files would furnish a master test piece or the exact instructions for making one, and then the user can be sure at all times that the maker is living up to his guarantee of the files being standard and uniform.

"Second, about the operator: 'File hard' depends upon the pressure and angle between file and object and the speed at which the file is moved. Which of these is important? Must we depend on the skill of a workman to regulate them?

"Next about the object being tested: Its response to filing depends upon its shape and its chemical composition. Shape is infinite, but there ought to be some measurable differences between a ¼-in. drill and a tool-maker's flat. Also what influence has alloy or scale?"

"File hard," as the article suggests, does depend upon the pressure and angle between file and object and the speed at which the file is moved (and so far we must depend upon the skill of the workman to regulate them). It also depends upon the file used in testing. The term file hard should mean that the article or metal cannot be cut or filed by a file specially prepared for testing purposes.

The hardness of a piece of steel that a file will cut depends upon the shape of the file, its coarseness of teeth and shape of same, as well as the hardness of the file itself. Hardened straight carbon tool steel, as hard as fire and water will make it, registers approximately C-64 to C-68 Rockwell, according to carbon content and the method of hardening. Even the hardest files will not cut this hardened steel. We have found that when this high carbon steel is tempered to 375° F. it still registers C-64 to C-66 Rockwell, but it is then possible to make a file to cut it. Nicholson testing files will cut test pieces tempered to 375° F. and registering C-64 to C-66. There are many shapes and cuts of files used for testing that will not cut steel as hard as this, but they are suitable for their particular purpose and method of use.

The term "file hard" also varies in exact meaning with every concern using a file for testing. There are several factors that interfere with the best use of the file in testing. The METAL PROGRESS editorial mentions the shape of the metal being tested, scale on the metal, and alloy in the metal. These all have a bearing on the use of the file:

Scale would have an influence,

While the Other Two Pictures in This Article Are Very Decorative, the Nicholson File Company's Laboratory Recommends the Technique Shown Alongside as the Best for Making Hardness Tests With a File

because it would be softer than the metal underneath.

Shape would have a big influence because it is much easier to file a narrow edge than a wide surface.

Alloy steel is denser and would, therefore, resist the file a little differently and it would be necessary to have a test piece of the same or similar material.

There would be a difference in resistance also on a polished piece as against a rough surface, and on a dry surface as compared to one wet with oil.

It becomes evident that hardness testing with files is an art which must be fitted to the needs of the particular product being manufactured and cannot at the present time be used as a standard for specifications. The terms of defining it are so flexible, and ordinary files vary so much, that it is not exact enough to be passed between manufacturing plants as a standard. But it can be and is developed in individual factories to an excellent method of determining the hardness of tempered metal products.

The skilled workman who uses a file for testing soon learns to allow for all the factors that influence, or might affect, the accuracy of the test and when using standard testing files the file test becomes an extremely useful measure of hardness.

The final suggestion made by the editor, that it might be possible to make files of different metals or with nitrided surfaces, which would have different degrees of hardness, or cutting ability, is a natural suggestion. For manufacturing reasons this has been found to be impractical. Experiments with files made from different alloy steels have shown that the cutting ability of a file is not determined entirely by the kind of metal from which it is made.

The idea of surface treatment of files to produce different degrees of cutting ability has been tried with some success. For instance, it is possible to make a file that will cut a test piece tempered to 400° F., but will not cut a test piece tempered to 375° F. Such files are very special and their cost of manufacture is too great to make them of practical use.

In fine, our experience leads us to believe that the best plan is to make the testing file to cut as hard a test piece as possible and then depend upon good judgment in its use.

* * *

Unless the Editor is mistaken, the above is the first authoritative discussion of the file test to appear in print. Other views on the questions raised, or data on specific practice, would be welcome.

COLD WORKING PROPERTIES OF WIRE ARE REDUCED BY PEARLITE

By B. L. McCarthy
Chief Chemist and Metallurgist
Wickwire Spencer Steel Co.
Buffalo, N. Y.

WIRE drawing, like many of our metal manufacturing processes, has developed its own technique without the assistance of the metallurgist. Preliminary treatment of the rods, shape of the dies, lubricants, annealing during processing, and routine testing are all matters which were developed by skilled artisans rather than educated technicians. True, the present standards are markedly improved over the standards of the early days, and present-day requirements could not be met without the assistance of the metallurgist.

However that may be, the metal itself demands definite processing along certain lines for the best results. We now see definite reasons for this, but in the early days results dictated the practice. A good example of this is found in the way heat treatment is varied with the carbon content. Low carbon steel is treated at a temperature below the critical point, while higher carbon steel is treated above the critical point.

In this paper, which is adapted from one given before the Buffalo Chapter, A.S.S.T., I am not going to try to discuss all the metallurgy of wire drawing, but will confine my efforts to a study of the flow of the metal, and some of the factors that influence it — notably as affected by the heat treatment, whether above or below the critical.

As is doubtless well known, wire drawing consists of introducing a long piece of steel, of given dimension, through a tapered die of a smaller dimension, and by so doing reducing its cross-sectional area and increasing its length. Most wires are round in cross-section, and nearly everyone thinks of round wires when "wire" is said. Nevertheless, many tubes and solid shapes, some quite irregular, are manufactured by exactly the same process, and my remarks will apply to them as well.

To accomplish the process, the rod to be drawn is first pointed. The pointed end is then passed through the die, gripped on the other side, and pulled through. As the wire passes through the die, the granular-shaped "equiaxed" crystals are elongated in the direction of flow, squeezed from all sides, and pulled from the forward ends. Whether or not each crystal flows uniformly is the chief factor influencing the extent to which the original metal can be drawn without damage.

Obviously, such a profound change in the internal structure of the metal is reflected in a change in its so-called physical properties, such as strength in tension or torsion, stiffness, hardness. The amount of change in any of these physical properties can be varied (within certain limits) even though the same amount of cold working is performed, by varying the condition of the steel at the start.

By controlling the physical properties of the metal prior to cold working, and the method of drafting, the manufacturer varies the physical properties of the finished wire. By "method of drafting" I mean the amount of reduction for each draft. Naturally, lower costs are had if the reduction per pass is large, but extra heavy reductions do not produce best properties in the wire. Drawing practice must therefore be scheduled with careful forethought as to the promotion of physical properties, and at the same time the maximum economy of operation.

Speed at which the wire is drawn through the die is one important factor of costs. Traditionally, wire drawing speeds are quite deliberate (as compared with other common fabricating or processing operations in this mass production era) and the draw benches ordinarily are built and geared accordingly. When these limitations are removed, the next limiting factor becomes the heat developed between stationary die and the wire drawn through. This heat not only destroys the lubricant but also affects the metal in the wire and the die. Even these limitations have been surmounted by copper wire drawers, and similar progress is being made in mills handling steel. Some of them have already introduced air-cooled equipment and water-cooled dies to permit an increase of speed.

As is commonly known, the hardness of metal increases upon cold working. This increase in hardness continues until finally a point is reached where the wire will not stand any further cold working and breaks. It is important that drawing be stopped before this point is reached; if further work is necessary to bring it to correct shape or fine gage, the wire, worked to a point close to its limit, can be heat treated, and cold working then resumed. The property of the metal to withstand cold working, without becoming brittle, can be termed its cold working property, and it is in the control of this property that heat treatment plays a very important part.

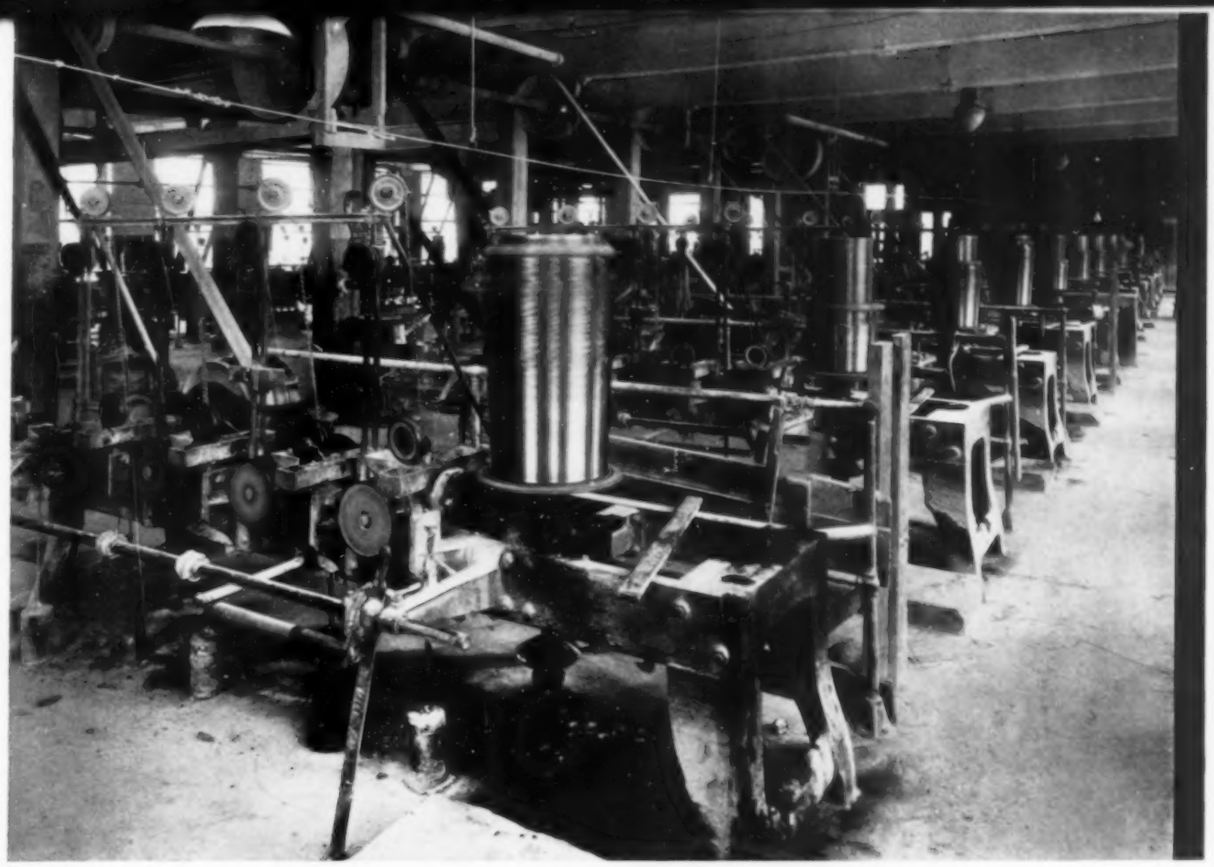
Reduction in cross-sectional area as the wire passes through the die is done in such a manner, when correctly done, that the disturbance to the crystalline structure is uniform throughout its cross-section. This is true in a broad sense; crystals near the surface are elongated to the same degree as those near the axis. But when a close study is made under the microscope, we find that variations in the flow of the metal exist, depending on the degree of uniformity within the metal, and also upon the fact that a soft, ductile crystal of one constituent of steel (ferrite) will flow much more readily than a hard plate or nodule of another micro-constituent (cementite).

We very often hear the expression "the hard skin" and it is the belief of many that there is a surface hardening effect of cold work. If we bear in mind that reduction in the die is mostly due to compression between the tapered sides of the die and the wire passing through, and to a lesser degree to the "necking down" effect of high tension from the wire block, it can be readily seen that the wire will be affected throughout its entire diameter. The pressure applied to the metal by the die is along a line perpendicular to the surface of the hole of the die. Inasmuch as this surface is not parallel with the axis of the wire, but slightly inclined, there is a tendency towards elongation of the crystals as well as direct compression.

It is clear that any variation in hardness existing in the micro-constituents of the metal will cause a variation in the amount of cold working, with the result that the harder portions are affected less by cold working.

Physical defects in the hot rolled rod, such as pipes and seams, seriously affect the cold working properties, not because of their presence alone, but because they are usually associated with segregation. Take, for example, a rod with a pipe in it; the pipe, of itself, will not seriously affect the flow of the surrounding metal, but the segregation that is very often associated with it will. A seam is not particularly harmful to uniform flow, but the decarburized ferrite regions usually associated with it are.

Heat treatment can either increase or decrease the cold working properties, depending



Battery of Continuous Benches, Palmer Works, Wickwire Spencer Steel Co.

on the temperature employed and the condition under which the treatment is carried on. In the literature these relationships are discussed as they affect steel of approximately eutectoid composition (0.85% C) to be made into high strength wire such as music wire, bridge wire, or stranded wire cables for hoisting or elevators. Specialized heat treatments known as patenting ("old process" and "new process") have been developed for the wire rod, largely without benefit of metallurgical science. It is not so widely known that the very much softer low carbon steels are equally benefited by preliminary heat treatment.

In discussing heat treatment and its relation to cold working properties, let us first consider low carbon steel. By low carbon steel, I mean steel with a carbon content under 0.20%. Its microstructure is composed of relatively large granules of ferrite with smaller grain-fillings of pearlite. Right here we have a marked difference in hardness and strength. The ferrite has a tensile strength of about 40,000 lb. per sq.in. and high ductility, while the pearlite has a tensile strength of about 110,000 and correspondingly low ductility. As a result of this difference, the ferrite will take most of the cold working; such non-conformity of flow will reduce the cold working properties.

To overcome this condition in low carbon steel, the wire drawer anneals it at a temperature below the critical point. This results in the formation of globular or "divorced" pearlite and free ferrite; the fine particles of cementite are distributed throughout the mass with the result that a greater general uniformity exists and the cold working properties of the more continuous ferrite are improved.

In the case of higher carbon steel (that is, steel with a carbon content above 0.30%) we have a large amount of pearlite and only a small amount of ferrite. To render such a structure homogeneous, the material should be heated to a temperature above the critical point, and held there long enough for the carbide and iron to diffuse into a uniform solid solution, and then quenched so as to prevent any free ferrite from separating out, yet not severely enough to form the harder constituents of troostite and martensite. This gives us a very fine structure known as sorbitic-pearlite, and as a result of the uniformity in hardness of the micro-constituents, the cold working properties of the metal are again promoted.

Because of the marked difference in hardness between spheroidal cementite and ferrite, and the relatively small amount of ferrite present in high carbon steel, a low temperature

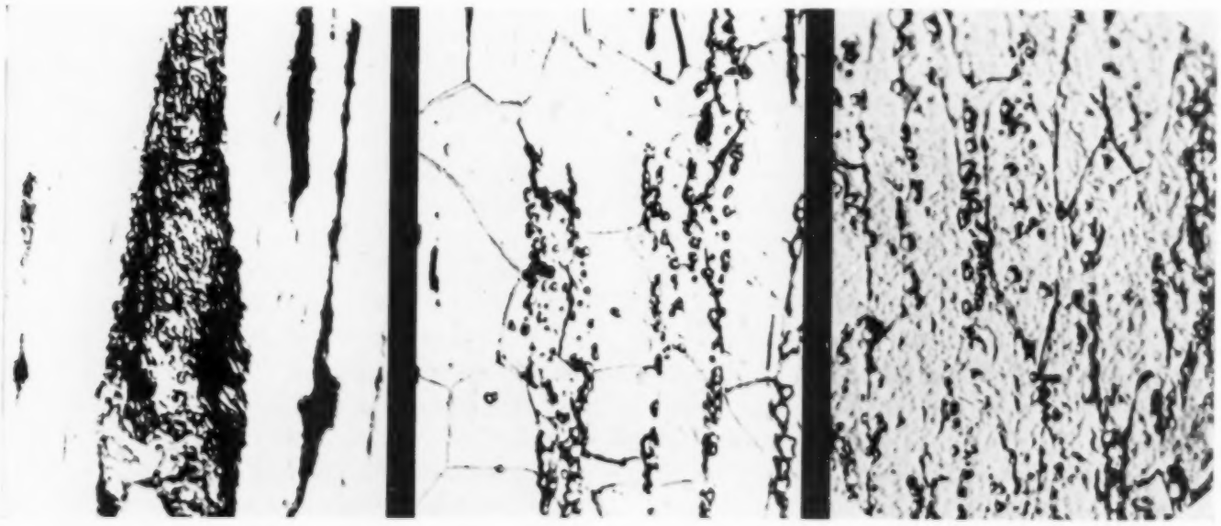
anneal cannot be employed. If it is done and the metal then drawn, you would find that the ferrite, being much softer, takes the cold working almost entirely, and since there is relatively little of it, it is quickly worked beyond its limit.

Laminated Pearlite in a 0.50% Carbon Steel Wire Rod Strongly Resists Deformation, the Free Ferrite Taking Nearly All the Cold Working in the Die. Photographed at 2000 diameters. Such steel should be patented, a heat treatment that breaks up the cementite plates in the pearlite into ultra-microscopic particles

A very interesting example of the effect of non-uniformity in structure is afforded in the study of the influence of axial segregation. In this case, we have a hard core in the center and a softer sheath on the outside. On wire drawing this material, we find that the softer outside flows readily, but the center resists the flow to the extent that numerous small fractures occur there. This is what the wire drawer calls "cuppy wire," because it breaks with a cup-like fracture. The center has been worked beyond its limit, and broken, while at the same time the outside portion could be worked further.

Non-metallics do not affect the cold working properties to the extent that is commonly believed. Because of their relative softness they b r e a k up under the pressure and do not seriously resist the flow. I do not mean by this that their p r e s e n c e should not be avoided, but it is my experience that non-uniformity resulting from faulty heat treatment can do more damage than the non-metallics which are commonly associated with open-hearth steel.

In my opinion, the element that contributes most to the non-uniform flow of the metal is lamellar pearlite, which offers marked resistance to plastic deformation. High carbon steel containing free ferrite is notoriously deficient in cold working properties due to the presence of this structure. It appears as though the alternate plates of cementite and ferrite are not drawn out or compressed to any large degree.



If an 0.08% C Rod Is Drawn 95% the White Ferrite Crystals Are Intensely Distorted, as Shown at Left, Yet Pearlite (While Drawn Out Somewhat) Has Many of Its Cementite Plates Unbroken. Annealing such a wire just below the critical breaks up the cementite into globules (center micro). While these round, hard fragments will not deform, they are embedded in continuous ferrite, and a more even flow in the die will r e s u l t. Note structure after further drawing, at the right. All views at 2000 diameters

Wire Containing Axial Segregation, Sectioned Through Center and Magnified About Four Times. Note the internal fractures. This wire is very weak and breaks with a "cuppy" appearance. Examination of the photograph reveals that the direction of cupping changes, indicating no general direction of flow. This tends to substantiate the idea that the large portion of the deformation in wire drawing is a result of compression, and not of tensional strain

This is undoubtedly due to the hardness of the cementite plates.

The necessity of breaking up this plate-like structure applies to low carbon steel as well as high carbon steel, and the structure that gives us maximum cold working properties is noticeably free from it. This is apparent when steel of eutectoid composition is cold worked. In this steel, we are able to develop the one constituent (pearlite) very prominently by proper heat treatment, yet the cold working properties are not increased to any great extent over a lower carbon steel containing some free ferrite. However, a patenting treatment, wherein the coarse pearlite is changed to very fine sorbitic-pearlite, increases the cold working properties greatly. In this structure the hard cementite is distributed in ultra-microscopic particles rather than in relatively enormous slabs.

There have been numerous theories advanced to account for the hardening effect of cold working. Two of these theories are worthy of some thought.

The English scientist Beilby, after years of experimentation, advanced the "amorphous metal theory." He found that a small amount of friction on the surface of a metal creates a thin coating of amorphous metal which is extremely hard. He applied this theory to the polishing of metallographic specimens, and it was his contention that the reason why crystalline structure of the metal is not readily apparent after polishing is because this coating of amorphous metal obscures the real structure. We etch the surface to bring out the structure; acid dissolves this film very readily. Going still further, he contended that the slip along the crystal surfaces resulting from cold working past the elastic limit creates amorphous metal on these surfaces and the hardening effect is proportional to the amount of slip and the amount of hard amorphous metal so developed.

Jeffries and Archer, in this country, later formulated the "slip interference theory of hardness." They do not confine it to cold worked metals only, but to hardness of metal in general. By this theory hardness is related to the resistance to slip set up by obstructions on the natural cleavage planes. As the metal is cold worked, there is slippage along crystal planes which offer the least resistance. This can go only so far when it is obstructed by interference of other crystals at the boundaries. In effect, however, the number of grains is increased, and the length of free slipping planes correspondingly decreased. As the pressure is continued other slips occur in different directions. As a result of continued working, we have an entirely new arrangement of much smaller crystals offering increasing resistance to slip.

It must be remembered that all of the slips mentioned are merely minute movements of crystallographic surfaces on each other without the destruction of molecular cohesion. When wire is overworked, this cohesion *is* destroyed, and in my opinion this fact adds support to Beilby's theory, for it might indicate that the hardening of the amorphous metal had been carried beyond its limit. On the other hand, if the amorphous metal described by Beilby quickly attains a definite hardness beyond which it cannot go, there is no reason why further deformation in the metal would not create new slips. By continually increasing the density and reducing the cleavage plane weakness, an ever-increasing resistance for the metal to plastic deformation would occur. This is only another way of saying "the metal hardens by cold work." This could continue as long as the movement was confined to slip in the crystalline material remaining, but a point would be eventually reached where the molecular cohesion would be destroyed and further deformation would result in permanent fracture.

Either of the above theories can be accepted, for they furnish a useful explanation for the hardening effect of cold working. Either will be a safe guide in the revision of wire-mill practice designed to produce higher quality wire at a lower price.

PULVERIZED COAL FOR FORGE FURNACES IS EXCELLENT AND CHEAP

By C. P. Blair and C. E. Pond
Norfolk & Western Railway
Roanoke, Va.

LAST February the Norfolk & Western Railway completed and put into operation a modern installation of heavy forge furnaces in its Roanoke Shops. It is notable because it uses pulverized Pocahontas coal for fuel, and because the escaping flame is passed through a preheating furnace before going out the stack. There are two batch-type high heat furnaces, duplicates except one is right hand and the other is left hand. The preheating furnace is placed between them and receives hot waste gases from either or both. The three, together with coal hoppers at the ends, occupy a floor area approximately 82 ft. by 12 ft. (exclusive of stack), and serve two Chambersburg steam hammers, one 4500 lb. and one 8000 lb.

This group replaced two coal-burning furnaces fired by hand and an oil-fired preheating furnace, and was part of a general improvement program in the forge shop. Before deciding on the pulverized coal furnaces careful study was made of furnaces using all the available fuels. Other plants were also visited by our engineers. Pulverized coal was selected as being the most satisfactory and economical fuel to use. That this decision is correct has been definitely demonstrated since the furnaces have been in service.

With the exception of fuel equipment and accessories, the entire project was constructed by our own men. The foundry made many special castings, the structural shop made the buckstays and much of the binding, the welding shop made the water-cooled doors and the stack. The pulverized coal transporting, feeding, and burning equipment was purchased from the Whiting Corp. It comprises a 5-ton weigh tank, pneumatic conveyors, two 3-ton storage bins, feeders, exhausters, burners and control equipment.

We at the Roanoke Shops had already had much experience with pulverized coal, since it has been used for generating power for some time. The smith shop adjoins the boiler room, and just inside the common wall was located a large storage bin. It was only necessary to run a gravity line from this, through the wall into the new 5-ton weigh tank; from thence the coal is conveyed across the furnace room through a pipe trench approximately 40 ft. long.

Coal is distributed by a pneumatic conveying system controlled from a signal board at the weigh tank. In order to describe the operation it will be assumed that storage bins for both fur-

naces (No. 1 and No. 2) need filling. The operator at the weigh tank signals by an electric horn that he is ready to begin transporting coal. The furnace operators recognize the signals and inform the weigh-man that the furnace is ready, by pushing buttons which light red lamps on the signal board. The weigh-tank operator then pushes buttons marked 1 and 2 on the signal board which unlatch the switching valves on the transport line and allow them to be opened by the furnace operators.

Interlocked System for Fuel

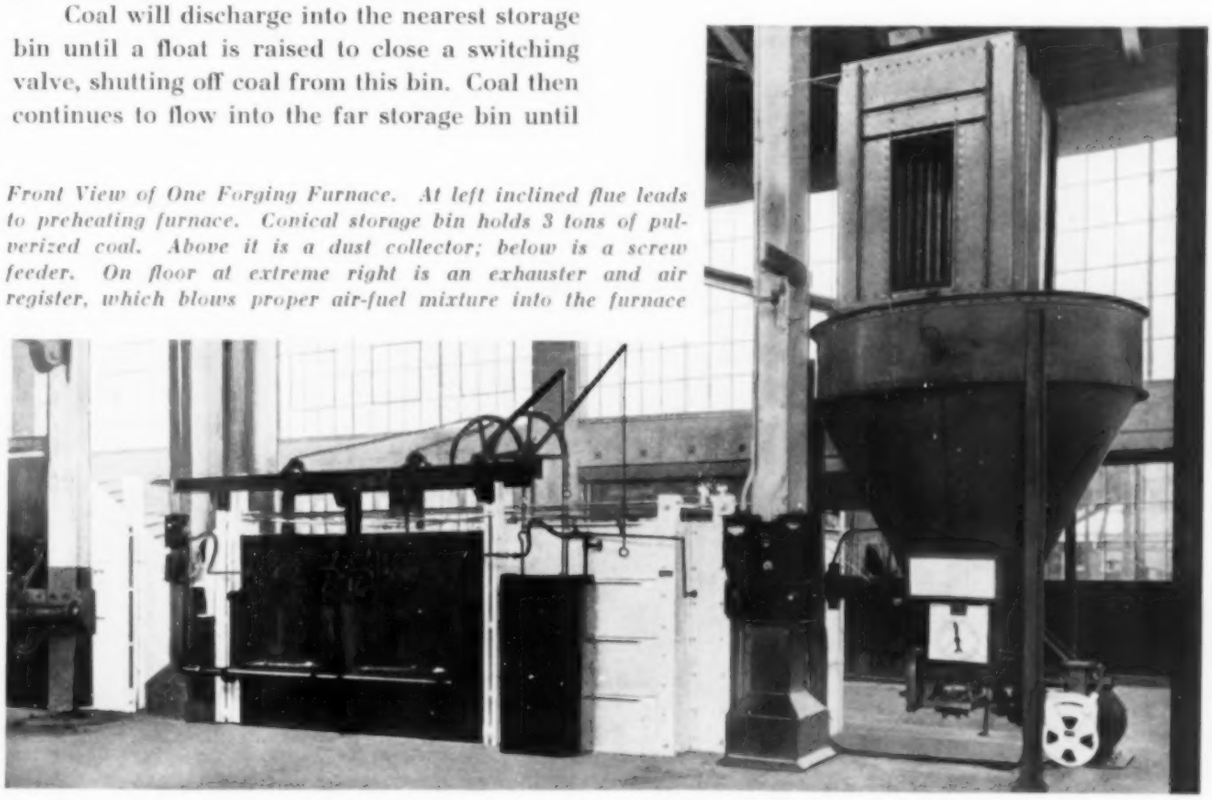
When these two valves are opened, blue lights burn on the signal board. The system is now ready for transporting the coal. At this time the weigh-tank operator opens an electro-pneumatic valve which admits compressed air at 30 to 40 lb. pressure to the top of the weigh tank and to a pneumatic feeder at the bottom of the tank. The latter aerates the coal in the feeder and floats it through a 4-in. transport line to the storage bins, about 500 ft. distant. Coal is transported at the rate of about 1000 lb. per min. Approximately 750 cu.ft. of free air is required per ton of coal transported.

Coal will discharge into the nearest storage bin until a float is raised to close a switching valve, shutting off coal from this bin. Coal then continues to flow into the far storage bin until the float in this bin also operates. When both of the switching valves are closed an electrical circuit is made which automatically closes the compressed air valve at the weigh tank, thus shutting off the coal supply. The system is so interlocked that coal cannot be transported if both switching valves are shut or if the manhole cover is open on either storage bin.

A dust collector is mounted on one of the storage bins at the furnace (as shown in the view on this page) with a vent pipe leading to the other bin. All air used for transporting coal passes through this dust collector, which separates and exhausts clean air into the shop.

Attached to the bottom of each storage bin is a motor-driven screw feeder, with variable speed transmission, which feeds the coal in the desired quantity into the suction side of an exhauster. Here it is picked up by the air stream, thoroughly mixed and blown into the furnace through a burner. Accurate regulation of the air-to-coal ratio for proper combustion is done by a simple segmental register, shown at the extreme right of the illustration.

The line drawings show the details of construction of the furnaces. Billet furnace No. 1



Front View of One Forging Furnace. At left inclined flue leads to preheating furnace. Conical storage bin holds 3 tons of pulverized coal. Above it is a dust collector; below is a screw feeder. On floor at extreme right is an exhauster and air register, which blows proper air-fuel mixture into the furnace

is not shown, but is the exact left-hand copy of the one drawn. The two billet heating furnaces are fired from opposite ends with one high-low velocity burner to each furnace. A funnel-shaped opening leads into a full-sized combustion chamber, thus providing sufficient space at the burner-end of these furnaces for complete combustion before the flame strikes the metal. Waste gases pass out of the billet heating furnaces through inclined ducts to the top of the preheating furnace, thence down through a slot opening at the very front of the arch, thence back through the preheating furnace into the base of the stack.

Reference to the drawing will show that these billet heating furnaces have hearth dimensions of 6 ft. 6 in. x 13 ft. 6½ in., of which 8 ft. is effective working space and the balance is combustion space. Inside height of these furnaces from the hearth to the spring of the arch is 33 in.

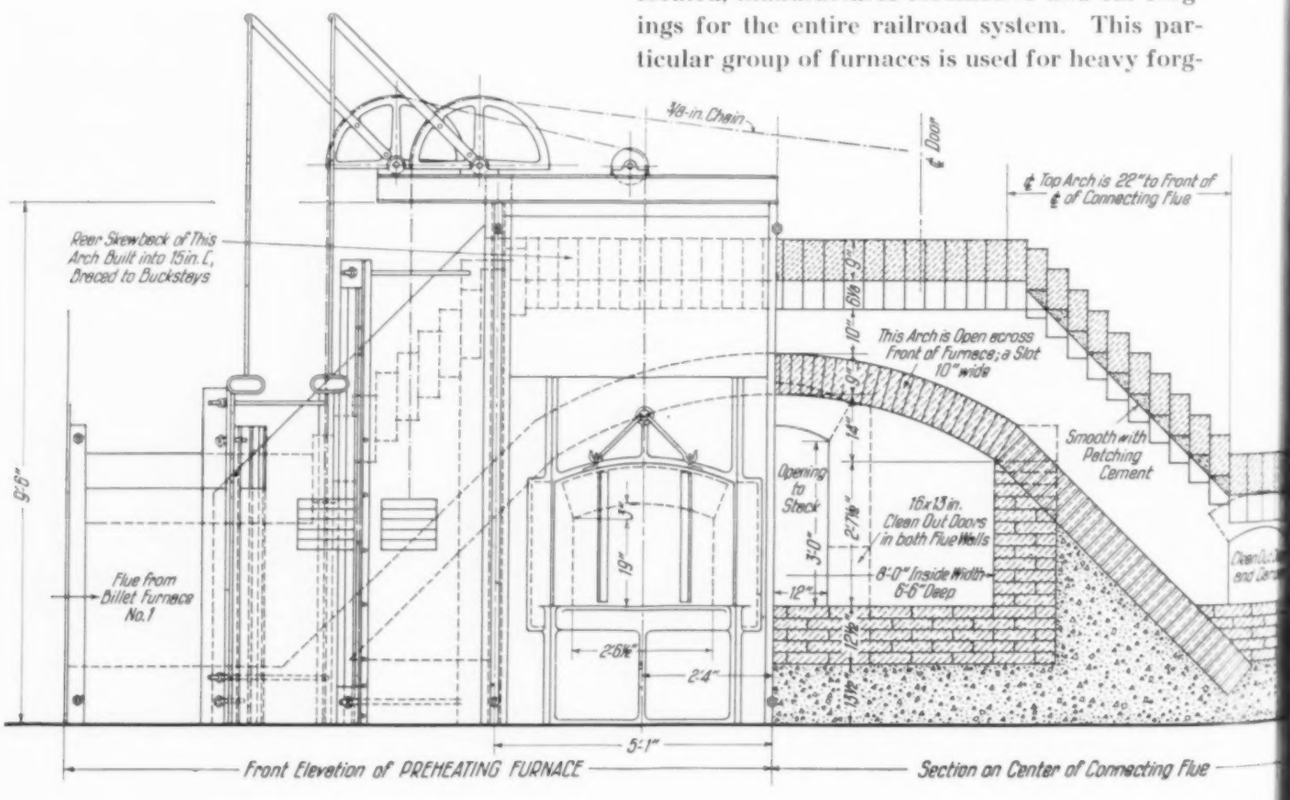
The furnaces are constructed of ordinary firebrick, laid with high-temperature cement and rigidly encased in a steel and cast iron shell securely tied together. Hearth is silica sand, and the working space is lined with silica brick. Doors on these furnaces are of ⅜-in. steel boiler plate welded into a water-jacketed frame to hold 4½-in. firebrick.

The hearth of the preheating furnace is 6 ft. 6 in. x 8 ft., all of which is effective working space. This furnace is also constructed of ordinary firebrick, laid with high-temperature cement and rigidly encased in a steel shell. The doors on this furnace, however, are not water-cooled, but are of cast iron lined with 7 in. of firebrick. Water-cooled doors are unnecessary on this furnace on account of the comparatively low temperatures.

A notable characteristic is that the roof of this furnace is a long, flat arch, 8-ft. span, the weight of which is carried back into the concrete foundation by the inclined firebrick floor of the connecting flues or ducts. These ducts are provided with cast iron doors for regulating the temperature in the preheating furnace.

The stack is constructed of ¼-in. steel plate welded together, and lined from bottom to top with circular firebrick 4½ in. thick. The stack is 36 in. inside diameter and 56 ft. high. Draft doors are located between the stack and the preheating furnace for regulating the draft in all three furnaces, and for clean out.

The forge shop, in which these furnaces are located, manufactures locomotive and car forgings for the entire railroad system. This particular group of furnaces is used for heavy forg-


⅛-in. Chain
℄ Door
℄ Top Arch is 22" to Front of ℄ of Connecting Flue
Rear Skewback of This Arch Built into 15 in. C. Braced to Buckstays
This Arch is Open across Front of Furnace; a Slot 10" wide
Smooth with Patching Cement
Opening to Stack
16 x 13 in. Clean Out Doors in both Flue Walls
8'-0" Inside Width 6'-6" Deep
Flue from Billet Furnace No. 1
9'-6"
5'-1"
Front Elevation of PREHEATING FURNACE
Section on Center of Connecting Flue

ings, such as locomotive axles, main and parallel rods, piston rods, guides, drawbars, equalizers, and so on. A majority of the parts forged are from carbon or alloy steel billets, but the furnaces are designed for temperatures sufficient for reclamation and welding of wrought iron scrap.

Reclamation of Wrought Iron

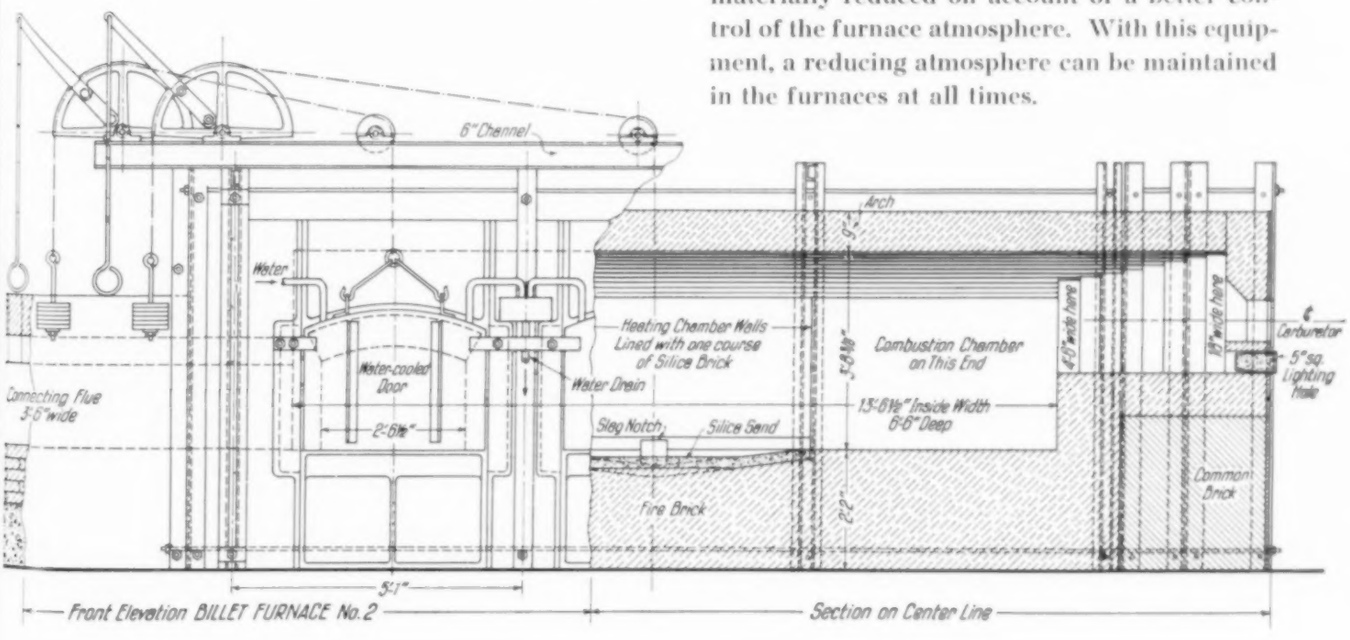
The latter work is one which may profitably be used for "fill in" work and converts scrap of low value into forging billets of high quality. It consists of box piling the selected scrap material into cubes, approximately 14 in. on a side, heating them to the dripping point and hammering them into billets approximately 4x11x40 in. in dimension. These billets are immediately recharged two high, again heated to the welding point and reforged. This results in double refined wrought iron suitable for drawbars, safety bars, and other heavy wrought iron forgings.

Temperatures in the forging furnaces range from 2200° F. for steel to 2800° F. for reclaiming wrought iron. The temperatures in the preheating furnaces can be regulated from a minimum of about 800° F. to a maximum of about 1400°. The miscellaneous work performed in these furnaces is of such a nature that automatic control of temperatures is not necessary. Experience has shown that the coal feeding and burning equipment on these furnaces permits a very close manual control.

The preheating furnace was constructed primarily to preheat billets of high carbon content, prior to exposing them to the forging heat, in order to avoid thermal ruptures. This is of course accomplished, but an auxiliary effect of the furnace is to increase the production of the furnace group. Handling of hot metal on peels is easily done by means of jib cranes set on either side of the doors.

Pulverized coal has been found to be a highly satisfactory fuel for metallurgical furnaces of this variety. In this we have verified experience in other big shops — notably Baldwin Locomotive Works, Eddystone, Pa. Although production has been relatively low and operation intermittent since this installation was completed at Norfolk, the economy of operation is evident. Our records indicate that we can now produce 8000 lb. of rough finished steel forgings with 3000 lb. of coal in an 8-hr. working day. This is at the rate of 750 lb. of coal per ton of metal heated. This performance could be materially improved if the demand warranted continuous operations. It must be understood when appraising this figure for coal consumption that the parts produced are finished forgings; it is necessary to reheat many of them several times before they are finished.

In addition to the economy of pulverized coal, the scaling of the metal heated has been materially reduced on account of a better control of the furnace atmosphere. With this equipment, a reducing atmosphere can be maintained in the furnaces at all times.



Another advantage of pulverized coal, which was not anticipated, is less wear on the furnace refractories. The furnace lining has a glazed, monolithic appearance. Spalling has been minimized. These furnaces have been in operation six months without any renewals.

No trouble has been experienced with ash. When the furnace temperature is above its fusion point the molten ash runs out through slag taps provided at the rear. When operating at a temperature below the melting point of the ash, the "fly ash" may either be sucked out through the stack by maintaining sufficient gas velocity through the furnaces, or the velocity may be reduced, the ash collected and cleaned out the side doors as occasion warrants.

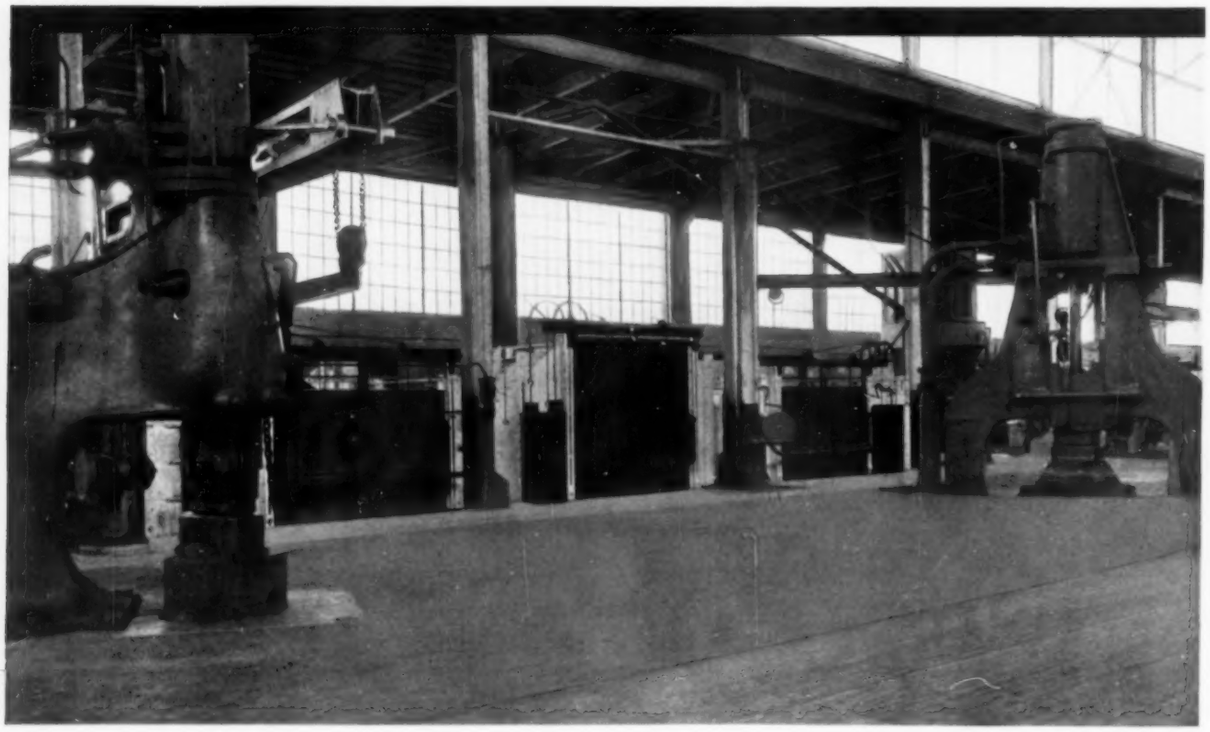
Fly ash has never discharged through the furnace doors under any operating conditions.

One Quarter of Coal Saved

As previously stated, these furnaces replaced two hand-fired coal forging furnaces and one oil-fired preheating furnace. Since their installation coal consumption has been reduced 25%. In addition, the oil previously used in the preheating furnaces has been saved, as this work is now being done with waste gases. We are unable to make an actual comparison between pulverized coal and fuel oil for this particular class of work, because coal has always been used in this plant. A theoretical comparison, using average thermal values of the two fuels, will indicate that 75 gal. of oil would be required to produce one ton of finished forgings as against 750 lb. of coal. (This is based on coal at 14,500 B.t.u. per lb. and fuel oil at 145,000 B.t.u. per gal.) Relative economies would depend upon the cost of oil and pulverized coal delivered to the furnace burner.

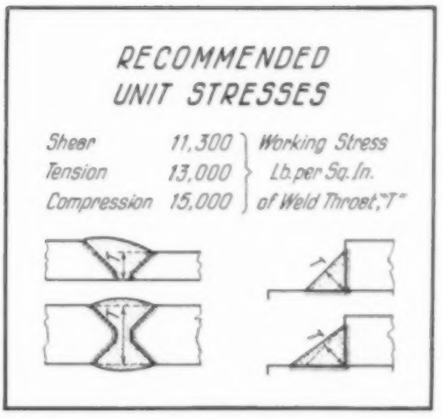
Experience with pulverized coal seems to indicate that a reducing atmosphere can be attained without incurring large losses, which are unaccounted for in the usual heat balance. It has been suggested that the losses due to unburned hydrocarbons when maintaining a reducing atmosphere with pulverized coal are lower than other fuels having a higher hydrocarbon content. However, no definite data are available. The efficiency of this particular furnace group is increased materially by the use of the preheating furnace, which recovers in a very simple manner much heat which would ordinarily be lost up the stack.

Modernized and Orderly Shop for Heavy Forgings



QUALIFIED WELDERS MAKE JOINTS STRONG & UNIFORM

By H. Malcolm Priest
Assistant Engineer
American Bridge Co.
New York



NEARLY a year has elapsed since the Structural Steel Welding Committee of the American Bureau of Welding published the report of its long investigations. In this interval the report has been widely recognized as an authoritative source of information and recommended procedure. Although devoted to structural welding, the findings are of such general interest that all users of welding can benefit if they are familiar with the results.

The investigation, which required five years for completion, had two principal objects:

1. To determine safe design values for various types of fusion welded joints under static loading, as commercially welded in structural steel fabricating shops.

2. To determine the degree of uniformity of workmanship which may be expected from the welders in such shops throughout the country.

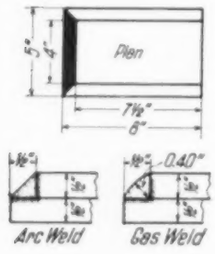
The aim of the Committee was not to conduct an academic study but rather to obtain a cross-section of commercial practice from which to draw conclusions and upon which to base recommendations. To this end, a large number of shops were invited to cooperate, and the participants in the complete investigation included three rolling mills, 39 fabricating shops, 61 welders, 18 inspectors, and 24 testing laboratories. A Canadian laboratory provided pilot information, based on the testing of specimens welded in three Canadian shops.

Qualification of Welders

With a view to insuring uniformity of the procedure in conducting the tests, a comprehensive set of instructions was prepared covering all details of the work from the selection of welders to the preparation of test reports from the cooperating laboratories.

Before a welder was permitted to weld the "program" specimens he was required to attain a specified standard of performance on two varieties of "qualification" specimens. The first is shown in Fig. 1 and is the so-called

Wedge Test for Qualification



wedge test. After making the weld and cooling, the bars were separated by driving a wedge between their free ends to cause the weld metal to rupture. The fracture was then examined for dimension, quality, and fusion and penetration at the root. The instructions specified that the fracture shall be "bright and dense, even textured, fibrous appearing or crystalline weld metal, irregularly torn and free from blowholes, slag inclusions, overlaps, and iridescent color."

The other form of qualification test was a butt weld from which tension coupons were cut. A pair of ½-in. plates, 9x12 in., were beveled on a long edge, butted and welded in specified position. Surplus weld metal ("reinforcement") was ground off, and the 18x12-in. plate cut into six 2x18-in. strips. The ones originally at the edge were rejected, the other four were reduced in width to 1½ in. midlength into the convential shape for a tension test coupon on plate. Three such specimens were welded in a flat position and two in a vertical position. In order to qualify a workman, it was specified that the test pieces must develop the following strengths:

For arc welders, an average ultimate strength for 20 coupons of 45,000 lb. per sq.in., with a minimum for any individual coupon of 40,000 lb. per sq.in.

For gas welders, an average for 20 coupons of 52,000 lb. per sq.in., with a minimum 50,000 lb. per sq.in.

At the time these requirements were set the usual values specified for gas welding were higher than those for arc welding. The conclusions of the report indicate that an average of 52,000 and a minimum of 45,000 lb. per sq.in. may be considered proper values for either process in structural work.

The results of the tests can best be presented by separate consideration of the qualification tests and those made upon the program specimens. The relation between the two groups will be treated later in this discussion.

Taking up the qualification tests first, the most important requirements were those relating to the tension test of 20 standard coupons for each welder. Of the 42 welders who prepared joints for the program, 34 fully met the requirements. Eight failed to qualify, but for reasons deemed expedient by the Committee they were permitted to weld program specimens. (All work was, of course, properly identified, so various results could be segregated and analyzed.)

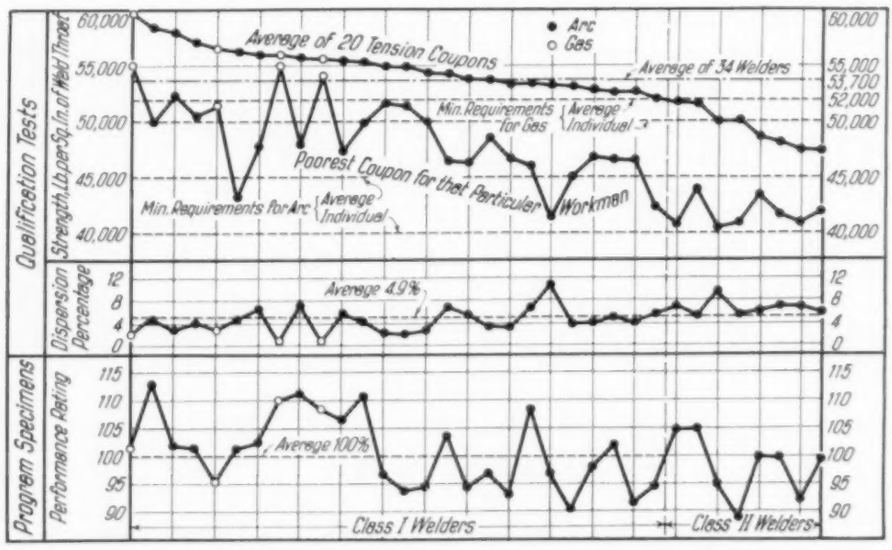


Fig. 2. Welders Whose Preliminary Work Had Highest Average Strength Made Joints Which Were Uniformly Good

Figure 2 shows the average of 20 coupons for each welder (arranged in decreasing order to the right), together with the strength of the weakest coupon. It can be seen that both arc and gas welders exceeded the requirements of the specifications by substantial margins. The trend of the minimum strengths is, in general, the same as for the average.

The amounts by which the strength of the

individual coupons departed from the average of the 20 coupons were computed as percentages of dispersion, then averaged for each welder, and plotted. It will be observed that the dispersion (which is a measure of uniformity) tends to increase with decreasing strength. In general, it may therefore be said that welders who weld strong joints also attain greater uniformity in results — that is to say, they are more reliable.

Strength of Butt and Fillet Welds

That part of the investigation relating to the program specimens covered the preparation and testing of 1395 specimens of various types and sizes of joints. Welding in the 39 cooperating shops was carried out under the supervision of the shops' own inspectors — a fact which adds weight to the results.

While this investigation was in progress the American Welding Society issued its "Code for Fusion Welding and Gas Cutting in Building Construction," and the unit stresses recommended therein were adopted generally with satisfaction throughout the industry. The test results secured by the American Bureau of Welding were therefore studied in the light of this Code. Since structural engineers are in the habit of basing their designs on average ultimate strength of their material divided by an agreed-upon factor of safety, similar factors of safety for welded joints were determined when referred to the specified unit stresses.

Thus, steel of ordinary structural grade averages 60,000 lb. per sq.in. ultimate strength, which, divided by a factor of safety of 3⅓, gives the unit working stress of 18,000 lb. per sq.in. now used for most structural designs. This same factor was deemed sufficient for welds to be used in such work.

A combined sketch and tabulation given below as Fig. 3 shows the strength of butt welds made in various ways. A weighted average for the 293 specimens is 49,600 lb. per sq.in. Since the unit working stress for butt welds recommended by the American Welding Society's Code is 13,000 lb. per sq.in. in tension, it would appear that a qualified welder, working in a good structural shop, would produce joints which would have a factor of safety of 3.81. In general, then, a welded structure properly designed according to the Code would have a higher factor of safety in the weld metal at the joints than at critical sections in the steel members.

Only ten of the 293 specimens showed factors of safety less than 3.00; the factor of safety for the minimum was 2.83.

Continuous and intermittent welds are seen to be practically equal in unit strength. For the same bar thickness, the strength of the weld was not affected by the form of joint.

¶ Before the results on fillet welds could be studied it was necessary to reduce them to a comparable basis. Welds were accepted as they came from the shops with their consequent variations in size. The minimum specified size was adopted as a conservative basis and the strengths of all over-sized welds were reduced by an appropriate amount. The over-all length of arc welds was reduced ¼ in. to allow for the crater and the imperfect fusion at the beginning of the weld.

It early became evident that eccentricity and its accompanying "prying effect" was an important factor in the strength of fillet welds. The various

Effect of Continuity		Effect of Form and Size			
4"	48,700	Weld Size	Square	Single V	Double V
7½"	48,600	¼ in.	54,100		
		⅜ in.	48,200	48,600	
7½"	49,700	½ in.		50,200	51,100
		¾ in.		46,900	46,900
11½"	48,100	1 in.			50,200
11½"	50,700	Weighted Average of 293 Butt Welded Specimens is 49,600 lb. per sq.in. Ultimate Strength in Tension			

Fig. 3. Butt Welds, Made in Structural Shops by Qualified Welders, Have About the Same Unit Strength, Regardless of Length or Thickness

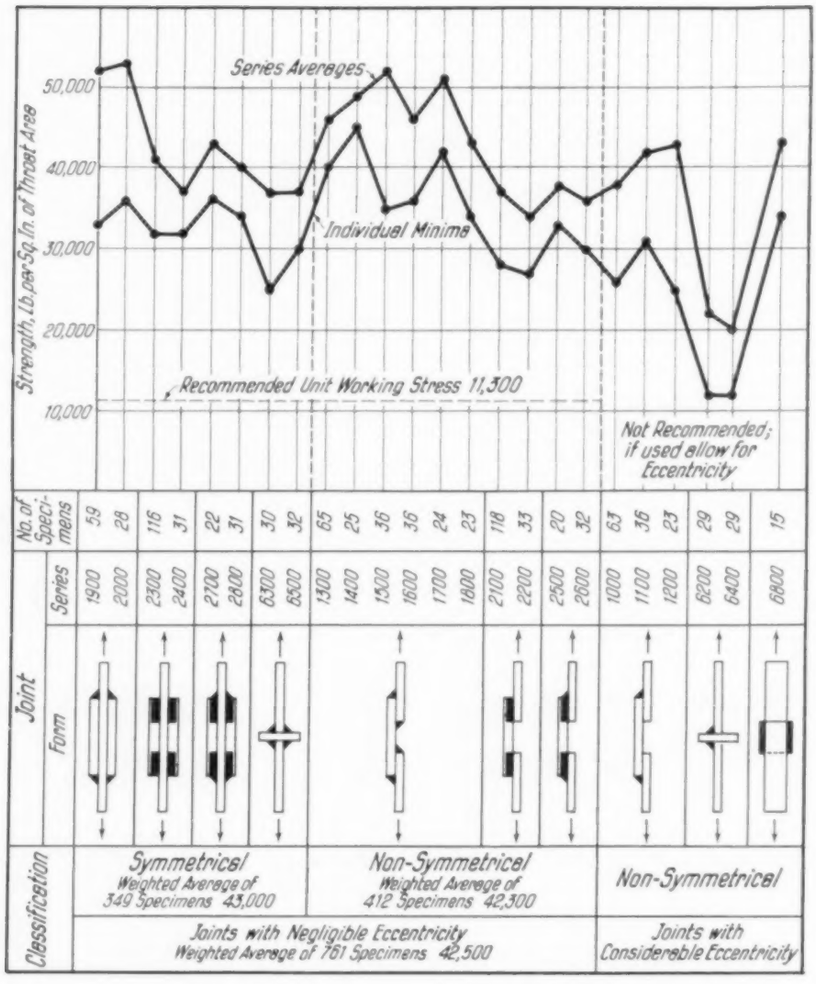


Fig. 4. Fillet Welds, as Used in Many Typical Designs of Joint, All Have Greater Strength Than Demanded by Building Code

forms of joints which were tested are sketched in the accompanying figure (Fig. 4). They are divided into two general classes — those with negligible eccentricity and those with considerable eccentricity. (The latter are not recommended for use unless allowance is made for the eccentricity.) Joints with negligible eccentricity are further divided into two groups, symmetrical and non-symmetrical specimens.

The diagram shows the average strength of the welds in pounds per square inch of throat area. The upper line represents the series average for each form of joint and the lower line gives the minimum result for any individual specimen. With a factor of safety of 3⅓ on the Code's working stress of 11,300 lb. per sq.in., the specimens should show an average strength of 37,700 lb. Actually both groups exceed this value. (The series numbers are to distinguish connections of one style made with different details and plate thicknesses.)

Prying Effect

A series of sketches at the foot of the opposite page illustrates the effect of flexure on fillet-welded specimens. For those with considerable eccentricity it should be noted that the weld is subjected to a prying effect which is resisted by internal forces having a small lever arm. When welds are placed on the ends of both overlapping bars the lever arm is materially increased and the bending is thereby thrown more largely into the bars. The same is true of specimens with side welds.

Figure 4 (left) is a composite result of various sizes of fillet welds, so it will be simpler to examine the results shown in Fig. 6 on the next page, obtained with the ⅜-in. welds, to appreciate the actual effect of eccentricity. Considering at first the symmetrical specimens, in which prying is practically absent, it appears that end welds are about 35% stronger than side welds, but they are also less uniform. Combinations of these two styles show an intermediate strength. The effect of prying is strikingly shown by comparing the several forms of symmetrical and non-symmetrical joints.

It is interesting to compare a welder's qualification tests with his subsequent performance on the program specimens. Because of the wide distribution of specimens among many welders a direct comparison was possible in only a few cases, but by computing a welder's performance in each specimen group the Committee was able to assign a percentage rating to

each welder. 100% was chosen as the average for each specimen group. These ratings for the participating welders are plotted in the lower part of Fig. 2 on page 30 which shows the results of the qualification tests.

The results for the first twelve welders are especially striking. With one exception, all of them rated over 100% in performance. A larger and more inclusive group designated as Class I was chosen, however, as being more representative of commercial welders. All welders in this class qualified with an average of more than 52,000 lb. per sq.in. and subsequently attained an average performance rating of 100.7%. This average of 52,000 lb. for the tension coupons is recommended by the Committee as a qualification requirement for both arc and gas welders, with a minimum of 45,000 lb. per sq.in. allowed for the weakest coupon.

Conclusions & Recommendations

Three conclusions of major importance might be stated here:

1. No harmful effect on the base metal due to welding was disclosed in these tests.

2. No important difference was found in the strength of welds made by either of the fusion welding processes employed.

3. In commercial practice a welded joint may be expected to have a strength within 12% of a general average for that type of joint, provided the welder has attained stated qualifications.

The Committee recommends that all welders on structural work be required to pass the following qualification tests:

1. The wedge test described and illustrated above.

2. A tension test, made on pieces A or pieces B, described below:

A. Two butt-welded plates as described on page 22, one welded vertical and one flat; the average strength of eight coupons is to equal 52,000 lb. per sq.in. with a minimum of 45,000 lb. for any one coupon.

B. Two double strap specimens, 3 in. wide, either end welded like Series 1900 (Fig. 1) or side welded like Series 2300 in each of the positions (flat, vertical, or overhead) which will be required in the welder's subsequent work. Each specimen is to show a minimum ultimate of 12,000 lb. per linear inch of weld.

The permissible unit stresses as specified in the American Welding Society's "Code for Fusion Welding and Gas Cutting in Building Construction" are safe and reasonable and are endorsed by the American Bureau of Welding, provided the welder has been qualified and provision has been made for bending stresses that may be introduced due to eccentricity. The recommended unit stresses, together with sketches to illustrate the throat dimension to which these values apply, are shown in a box near the head of this article. Proper design and correct workmanship will undoubtedly result in a satisfactory structure, as far as strength and reliability is concerned.

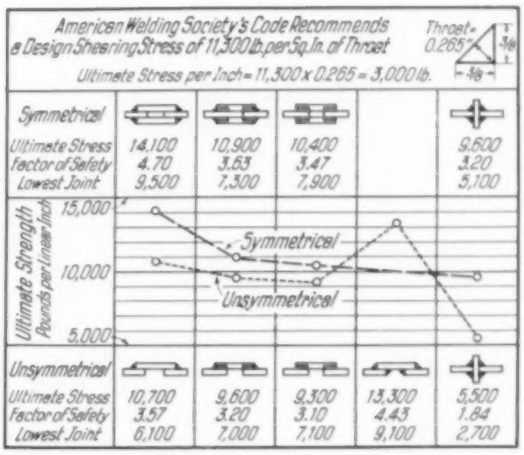

American Welding Society's Code Recommends
e Design Shearing Stress of 11,300 lb. per Sq. In. of Throat
Throat = 0.265 T
Ultimate Stress per Inch = 11,300 x 0.265 = 3,000 lb.
Symmetrical
Ultimate Stress 14,100 10,900 10,400 9,600
Factor of Safety 4.70 3.63 3.47 3.20
Lowest Joint 9,500 7,300 7,900 5,100
Ultimate Strength Pounds per Linear Inch
15,000
10,000
5,000
Symmetrical
Unsymmetrical
Unsymmetrical
Ultimate Stress 10,700 9,600 9,300 13,300 5,500
Factor of Safety 3.57 3.20 3.10 4.43 1.84
Lowest Joint 6,100 7,000 7,100 9,100 2,700

Fig. 6. Symmetrical Joints Are Stronger and More Uniform Than Non-Symmetrical Joints

Fig. 5. Lever Arm Is Increased in Non-Symmetrical Welds by Welding Both Overlaps

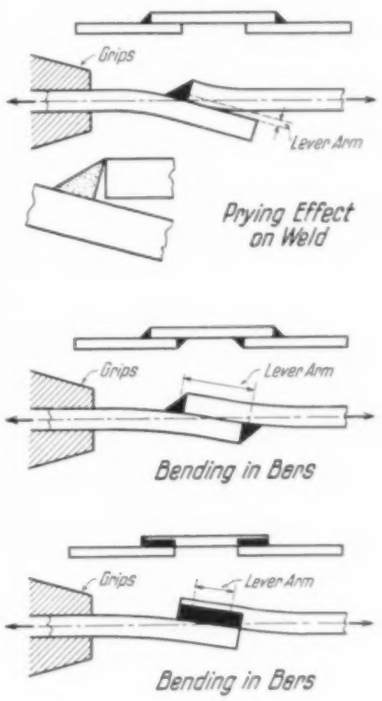
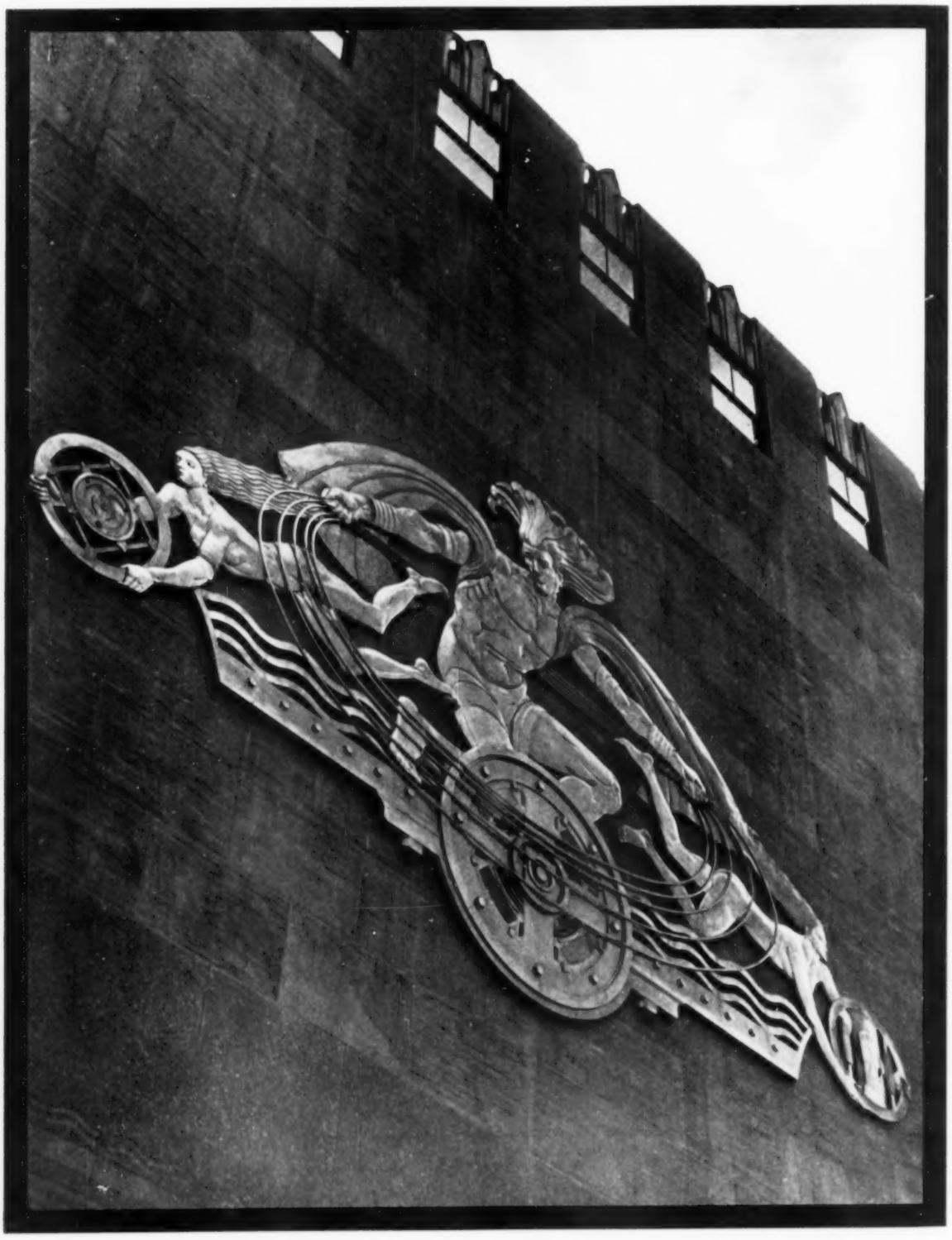


Photo by Browning, N. Y.



Artists Discover Metal

A REVIEW OF THE PITTSBURGH STUDIES INTO STEEL MANUFACTURE

By the Editor

IN A TALK in 1928 on The Industrial Pioneers, Charles M. Schwab, Chairman of the Board of Bethlehem Steel Corp. and President of the American Iron and Steel Institute, emphasized the relative intricacy of our present problems as compared with those of a former generation and observed, "The greatest work that is now being done for the improvement of industry is in the laboratory of the research worker."

Once a year, at the meetings of Carnegie Institute's Metallurgical Advisory Board, one can see how this improvement is brought about in Mr. Schwab's own industry.

* * *

A LITTLE HISTORY will serve as background: Carnegie Institute of Technology was organized as a trade school in 1905 and gradually developed into a technical college as certain of its departments proved to be of great merit, and attracted numbers of students seeking advanced instruction. Unfortunately the same developments did not occur so rapidly in coal and iron (the basis of the founder's fortunes), and by 1919 it became apparent to the President of the Institute, the Director of the Bureau of Mines (its largest experimental station adjoins the campus), and the leading industrialists of western Pennsylvania that all three groups should cooperate in a renewed effort to train young men and to study some pressing problems of the coal and iron industries. Consequently a Mining Advisory Board was created to raise supplementary funds and map a plan of action, followed four years later by a similar advisory board in metallurgy. As an additional effort in extending the metallurgical work, Dr. Baker, the president of Carnegie Institute of Technology, organized a Bureau of Metallurgical Research with a permanent scientific staff devoted entirely to fundamental investigations in the science of metals.

Wall ornament at Radio City of sheet metal, a hand hammered plaque made in repousse by Oscar B. Bach, symbolizes the relationship of dynamo and wired currents with microphone and photo-electric cell. Bodies of the figures are aluminum, hair is copper, draperies are bronze, and arm bands of stainless steel. Dynamo, wires, and electric waves are of stainless steel; horizontal beam is of aluminum with stainless steel bolt heads

* * *

IN 1926 the Metallurgical Advisory Board became convinced that the work under its direction should conform to a well-ordered program. It recognized that at least five years would be required to get very far with the studies into the making of better

steel that it proposed to undertake, and pledged the finances for that period. Bureau of Mines agreed to move its electric furnace laboratory and numerous personnel from the West Coast for such an investigation. Carnegie Tech furnished the services of several research fellows. Industry raised funds for materials and supplies and for salaries of a number of men to carry on correlated investigations in the plants.

In 1929 this work on the physical chemistry of steel making was at its peak. Twenty-four men were employed full time and about $60,000 was expended directly on the work. To this should be added a proportionate amount of supervision and overhead. Doubtless the entire 5-year program has cost about $250,000 — quite a sum of money, even in the old happy days.

What have we got for it?

Two things of great value (aside from a stimulus to the metallurgical school at Carnegie Tech — a byproduct which might easily be the most important of all): First, a body of new information about the physical chemistry of steel making. Second, a translation of these scientific facts into practice.

* * *

IRON OXIDE is at once the principal reactive agent in the refining of molten steel and the cause of many obscure irregularities in the finished product. It is at once a purgative and a poison. Therefore the 5-year program was wisely concentrated on the study of this substance — its solubility in molten steel and open-hearth slags (and the equilibrium between the two) and the methods of eliminating it and its reaction products, which are the principal nonmetallic inclusions in solid steel.

Under the energetic direction of C. H. Herty, Jr. (then of the Bureau of Mines' staff), these problems were attacked so successfully that the first phase of the study has been completed. We now have definite information on the amount of FeO which can be dissolved in iron at various temperatures and under various slags. Auxiliary studies of importance have also been undertaken, such as the melting of iron alloys without contamination, the identification and quick quantitative separation of oxide particles in steel (an achievement of G. R. Fitterer and associates in the Bureau of Mines), and the viscosity of slags. Information on this last subject is essential to the problem of removing the final traces of oxide from the steel before teeming it into the ingot mold, for good steel must be cleaned up by forming a liquid oxide mixture with a low melting point, insoluble in molten metal.

* * *

SPECIFIC DATA such as the above might well be worth many times the total cost to future industry. But the 5-year program was sharply differentiated from other such efforts by carrying the results into the cooperating steel works immediately, rather than waiting for the arrival of some rare genius who could interpret the meaning of such physicochemical mysteries as "distribution coefficient" to the melters. This important work was intrusted to C. F. Christopher, a metallurgical engineer who was qualified from work in the open-hearth department of one of the large Pittsburgh plants to give valuable advice to operating men in their own language, and with the earmarks of authority.

Furnaces ranging from 40 to 250 tons capacity have been closely studied in an attempt to determine how rapidly the slag and steel approach their theoretical relationships. The problem here is economic as well as scientific — for instance, the laboratory indicated that the cleanest steel is made under a slag with the lowest FeO. Plant research alone could determine what the lowest practicable content of iron oxide in an open-hearth slag is. Such plant research required an industrial organization that was willing and some investigators who were competent. Both of these the Advisory Board provided.

At least two important results have thus been achieved.

In the first place, the tone and precision of operations in all the cooperating plants have been largely increased. Rejects due to open-hearth troubles have been materially reduced. Surface defects (and chipping costs) have also gone down. This pronounced improvement in the manufacture of high-grade steel is now working out from the Pittsburgh center into the

whole American industry. While it is hard to place definite figures in dollars and cents on these items, undoubtedly the entire quarter million the work has cost has already been saved by men in various open-hearth shops wise enough to modernize their practice.

In the second place, the Advisory Board's employees are now able to act as a steel works clinic. A telephone call from any point in the Pittsburgh district will bring one of them to the side of an ailing furnace within an hour, ready to salvage a heat. Doubtless if such services had been charged for at the scale of fees we are accustomed to pay our medical and legal advisors, the entire research would not only be self-supporting but more highly regarded by the industry.

* * *

In January of this year, the Bureau of Mines withdrew from the joint effort, the original 5-year period having been completed. Considerable unfinished work remained to be done on the action of various deoxidizers added in the furnace and in the ladle. Silicon, manganese, and aluminum had each been studied separately in this respect, and some work done on double alloys. Silicon-manganese ferros appeared to be specially interesting, so five men have been retained in the employ of the Metallurgical Advisory Board during 1932 for further plant studies to check the theoretical conclusions.

Their success with silicon-manganese deoxidizer may be gaged by the speed with which their ideas have been put into commercial practice: Four ferro-alloy manufacturers are producing the recommended ferro, which is used on all the heats of medium hard grades in four of the largest open-hearth shops in the country. Savings of 15 to 30c worth of ferro-alloys for every ton of steel are reported by the superintendents, to say nothing of a noticeable reduction in percentage of open-hearth rejects. Say the average is 20c a ton direct saving from the discoveries about deoxidizers. Even in the year of deepest depression this saving can be made on a million tons of steel. Simple arithmetic shows that this one discovery and adaptation to plant practice was worth $200,000 to the American steel industry in 1932 alone.

It is surprising to learn, therefore, that the Advisory Board is compelled literally to pass the hat for a beggarly $20,000 needed to carry on through 1933. The steel industry appears to have accepted with reservations (if at all) Mr. Schwab's words quoted at the outset! If only the discoveries of research, now so freely given, could carry a charge for royalties the problem of finances would be settled forever.

* * *

That the work going on in Pittsburgh has been appreciated by all who knew about it is proven by the steady growth of the attendance at the annual open meetings, until now they are a convention of Who's Who in Steel Metallurgy. It has been an annual stock-taking into the current state of knowledge about steel making.

Such a means of disseminating information is quite valuable. More and more frequently is heard the complaint that it is all but impossible to keep abreast of developments in the field of metals despite the publication of extensive abstracts.

If this is admittedly true of trained engineers and scientists, how much more difficult it is to get important facts routed through into the heads of busy operating officials and departmental formen! Those in charge of research work complain that so many demands are made upon the time of their investigators to record and explain the import of their findings to the shopmen who are to use them, that there is little time left for the work for which they were really hired.

This problem of keeping practice abreast of theory is one which will necessarily be given increasing attention in the future. The successful translation of the Pittsburgh experiments into open-hearth practice shows that it can be done by men who have been some time in operating jobs, but not so long that they have forgotten all their textbook schooling.

If captains of industry are as astute as most Americans believe, they will reach out quickly for a lot of such men who are now unfortunately idle, and organize them into an "intelligence department" to translate the scientific code into shop English and shop practice. But they won't — they'll have to be sold the idea!

LOGICAL DEVELOPMENT OF AIRSHIPS FOR FAST OCEAN TRANSPORTATION

By Dr. Karl Arnstein
Vice-Pres., Goodyear-Zeppelin Corp.
Akron, Ohio

COUNT Zeppelin's plan to conquer the air by means of large rigid airships seems to be destined to go along fighting for recognition without attracting more than passing notice. Nevertheless there must be a reason why a group of experts and well-informed business men are partial to such an investment while the man in the street has remained a little dubious about the commercial possibilities of the airship.

There are several logical explanations for this distorted viewpoint. Perhaps the best single reason for this unfavorable publicity lies in the large size of the units. A misfortune to an airship, like that to a steamship, assumes the size of a catastrophe because of the large number of persons involved. Yet there are probably a great many travelers who do not realize that a regular scheduled trans-oceanic passenger and freight service, via air, has been in operation during the past year.

What, then, are the fundamental reasons why the airship has proven successful in this field where other means of high speed transportation have not yet been able to supply an acceptable performance?

The airship is a buoyant craft, freely floating in the air. It can maintain its altitude without forward motion and power plant failures do not interfere with its ability to remain aloft. Its forward speed may be adjusted through a wide range from the slowest form of motion up to the airship's top speed. There are no space restrictions in the passenger accommodations and bulky cargoes may be carried without difficulty. The tremendous lifting capacity of the larger ships permits fuel loads so large that it is possible to fly half way around the world without refueling, while their payloads are measured not in pounds but in tons.

All of these characteristics combine to fit the airship for certain definite fields of accomplishment. It can carry large payloads over long distances at comparatively high speeds. Due to the buoyant nature of its lift it is best adapted to long range flights over regions where intermediate landings are impossible, either due to meteorological factors or to the nature of the terrain. These are features of the airship type which exist today and have existed since the airship was first conceived.

Count Zeppelin in 1896 predicted that large

Principal Metallic Materials of Construction Are Strong Aluminum Alloys and Steel Wire and Cable

rigid airships would be useful for military purposes, exploration and world commerce. Let us pass over the intervening 40 years and see how the Count's original proposals have been vindicated by modern airships.

Military Purposes — In answer to the question "Does the airship have any military value?" it is only necessary to note that the Allied Powers were in such a state of mind at the end of the World War that the construction of military Zeppelins in Germany was absolutely forbidden.

Exploration — One of the most successful pieces of polar exploration during the past decade was that carried out by the Norge. This airship flew from Kings Bay over the North Pole to Alaska.

Riiser-Larsen, the navigator of the Norge, writes: "Time after time we congratulated ourselves that we were aboard an airship and not in a flying machine." Since Larsen, himself an airplane pilot, had flown with Amundsen to within two degrees of the North Pole only the year before, we can assume that he was quite familiar with the operating conditions.

Commercial Uses — Let us examine the transportation field and see where the airship fits into the scheme of things.

Undoubtedly the primary requisite of any vehicle used in a commercial transportation system is safety. Next in importance is performance, which may be termed as that quality which determines the type of service for which the vehicle is fitted and fixes its economic merit. The next factor is speed, which must be considered since transportation always requires time, and to business men, time is money. In addition, when we are transporting passengers, we must specify that our vehicle shall be as fast as possible, without sacrificing comfort.

Now these four attributes of safety, performance, speed, and comfort will be found to exist to a greater or lesser degree in all forms of transportation on land, water and in the air. The differences between various vehicles are due to the accentuation of certain of these features. The traveling and shipping public makes a choice according to the particular attribute which is of the greatest importance at the moment. It is due to this item of choice or variation in the market for transportation that it is possible for so many types of vehicles to be in existence at the same time. Standardization is impossible as long as the tastes of the customers and the services to be performed vary over such a wide range.

I am inclined to consider these means of transportation as interrelated rather than competitive. Naturally, when we have so many different vehicles, there may be a tendency for their fields of utility to overlap, but a critical analysis will generally show that one of these apparently competitive vehicles is supplying a slightly different type or quality of service than the other.

Effect of Engineering Developments

Due to the diversity of the transportation field, improvement does not come to all vehicles at exactly the same time. There have been

many outstanding inventions such as the air brake, the Pullman car, the pneumatic tire, the four-wheel brake, and the gyro-stabilizer, but you will generally find that for any innovation you are able to name in one branch of transportation, you can probably name another invention in another branch which has preserved the relationship which originally obtained between the spheres of usefulness of the two branches.

One cannot escape the conclusion that mechanical inventions in one field of transportation will make themselves felt in all other branches of the art.

Most of us can remember the advent of the small, light-weight internal combustion engine and its revolutionary effect upon the world's transportation system. The automobile did not immediately become the world's only motor vehicle however, for the invention was equally applicable to the motor boat, the airplane, the airship, and to the railroads.

Developments in aviation have always been intimately connected with those in the automotive field. During the War German aircraft builders abandoned the use of gear drives for propellers since they felt that reliable light-weight gears could not be obtained for the horsepowers they were using. Today the automotive gear designers have been able to supply gears which are quite acceptable, and as a result we have been able to improve our propeller efficiencies and to place our engines wherever they are most desirable.

Aviation has given the automotive industry any tendencies it may now have toward streamlining with the corresponding improvements in speed and economy. Development of airship engines has contributed to fuel economy for all types of engines. The principles of light weight design are now being applied in the trailer and tank wagon fields while the improvement in automotive fuel is, in some measure, to be charged to aeronautical developments.

Count Zeppelin borrowed one of his early designs of an articulated airship from railroad practice while the Pullman type of sleeping accommodation is used in the Los Angeles and the Graf Zeppelin.

The aircraft industry and automotive industries have helped the railroads by supplying the basic ideas for the high speed trains and branch-line cars with streamlined bodies, rubber-tired wheels, and mechanical drive from gasoline and Diesel engines.

The airship can truthfully claim the credit for the existence of the structural aluminum alloys, for without the stimulus of airship designers, no development work would have been carried out in this field.

The airship industry tries to take advan-

A Great Variety of Metals in the Power Plant. Supporting truss is chromium-molybdenum tubing, welded and heat treated; shafting and gears are of alloy steel. Exhaust manifold is stainless steel; exterior risers with fins are ingot iron; first condenser bank is low carbon steel, upper condenser banks are aluminum alloy

tage of the possibilities that develop in any kind of material. The Material Testing Section of Goodyear-Zeppelin Corp. must keep posted on all developments in the field of structural metals, heavy and light alloys in sheets, bars, and castings. We are interested in steels of high strength, in steels of high temperature resistance, and in steels of high corrosion resistance. We use aluminum in practically all its alloys and also magnesium, and we are vitally interested in the latest efforts to make use of beryllium in aircraft structures.

Need for Better Metals

Progress in the airship art depends on the progress made in bettering our materials. Metallurgical developments in all of these fields will undoubtedly be of great help to the aviation industry, but they will simultaneously cast their shadows upon all branches of transportational science.

I have gone to considerable length to point out the interrelation of all forms of transportation and to establish the conception of a group of transportational means, each one of which has, and always will have, a particular field of activity in which it will prove the most practical and economical vehicle. Such a conception of the transportational system is necessary if we are to be able to understand thoroughly the airship's field of utility.

In the field of transportation by air, there are two alternative means of travel now in existence. The most common of these is the airplane, which is primarily a high speed vehicle, cruising from 100 to 200 miles per hr. and carrying relatively small payloads over relatively short distances. The airplane will continue to serve people who must go somewhere in a very limited time and are willing to pay for the extra speed by putting up with a little less safety, a little more noise, and possibly with some air sickness during their flight in order to arrive at their destination in a minimum of time.

The large rigid airship offers a service of a somewhat different character. It provides speeds less than those of the airplane but still several times greater than those of any surface vehicles which might be employed for similar types of service. It can carry large payloads over large distances in safety and comfort and at a rate which is not out of proportion to the increase in speed which it furnishes.

Summarizing its advantages, the airship supplies speed, safety, comfort, and adequate performance to enable it to engage in world commerce.

Proof of adequate performance of airships in commercial service dates back to 1910, when Count Zeppelin formed the "Delag" or German Airship Transportation Company for carrying on regularly conducted commercial trips between German cities. This organization built up an excellent operating record and was so successful that six ships were eventually owned and operated. Before the service was interrupted by the War, "Delag" had made some 1600 flights and carried 34,228 passengers.

Immediately after the War, the Bodensee, a small 800,000-cu.ft. rigid airship, carried 2400 passengers and 1800 lb. of cargo on a route between Friedrichshafen and Berlin. The ship made 103 flights in 98 days before she was turned over to Italy by order of the Inter-Allied Air Control Commission.

In the meantime the Goodyear blimps had been steadily carrying on commercial operations on a small scale. From 1925 to date they have flown 1,052,855 miles and carried 92,874 passengers. During this period no passenger has been injured in any of the Goodyear operated airships.

The best commercial record for a large airship is undoubtedly that presented by the Graf Zeppelin. Up to January 1, 1932, she had made 232 voyages, a total distance of 218,642 miles at an average speed of 62.5 miles per hr. The total number of passengers carried was 6,778.

During the year 1932 the Graf has been continuing her program of short passenger cruises over the Mediterranean and around Europe and has just completed a series of 18 scheduled commercial trans-Atlantic flights from Friedrichshafen to Pernambuco, a distance of about 5000 miles. This schedule was adhered to with clocklike precision.

I believe these statistics definitely prove that the true field for the airship lies over the oceans. The long ocean routes allow ample areas for the use of "weather map flying"; this is the tech-

nique by means of which airships detour around serious depressions and other adverse meteorological conditions in order to pick up tail winds and improve the time of crossing.

Naturally, too, this particular field offers an economic reward, for there are thousands of trans-oceanic passengers and many tons of mail sailing across the oceans every week. A small percentage of this traffic will be willing to pay a premium for speed, and it is this small percentage for which we propose to create an airship service.

What are the possibilities of developing a high speed service with existing types of equipment? Today there are only about five Atlantic liners capable of cruising at speeds over 25 knots. Their operating expenses are so large that these ships are placed on frequent sailings only during a few months of the year. The trend in naval architecture is therefore toward a resonable amount of speed and a more luxurious type of accommodations.

We must agree that there are no airplanes now in existence which are capable of performing a safe, regular, year-round mail service across the North Atlantic ocean. Improvements may be made and the airplane may eventually be able to make the crossing with some useful load; however, such improvements will also have improved the performance of airships by a similar amount and its relative economic superiority will remain unchallenged.

The field for the large rigid airship is clearly defined and the only objection which now faces us is the lack of legal precedent and Congressional statutes which authorize this type of transportation and assist it in its pioneering stages, while the passenger revenue is being built up.

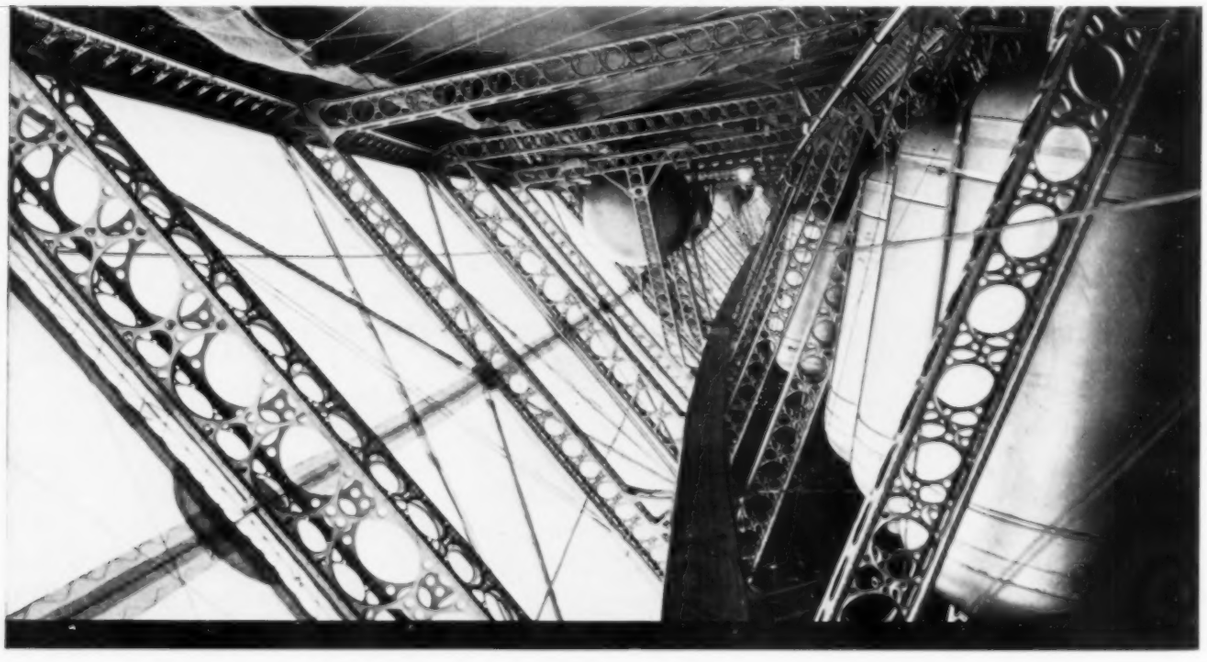
The Merchant Airship Bill now before Congress has two main purposes:

1. To place an American airship transportation company engaged in foreign commerce on a parity with steamship lines in the matter of rights and liabilities toward passengers and shippers.

2. To provide authorization permitting the Post Office Department to contract for the carrying of foreign mails by airships on a reasonable basis.

As soon as such enabling legislation is passed, we will be in a position to approach the financial groups and to interest them in this new and coming phase of transportation. We who have struggled with the airship through its many periods of adversity and have gradually overcome the numerous setbacks of an infant industry feel that the goal is now in sight.

Welded Fuel Tanks of Aluminum Sheet Alongside the Cat Walk; Gas Cells Overhead



ZINC ALLOYS FOR DIE CASTING RECENTLY IMPROVED

By J. B. Nealey
American Gas Association
New York

DIE CASTING is such a rapid manufacturing process for parts requiring unblemished surfaces and relatively precise dimensions that it has been widely employed in mass production of innumerable tools, instruments, and devices. The incident economies have been listed so often and are so well recognized that they need not be restated. Therefore, any intelligent production executive, or designing engineer, in considering the materials for a new machine part, will include die castings in the list of possibilities as a matter of course.

Among the factors which must be weighed in appraising their utility for a given job may be included (*a*) the usable alloys, (*b*) strength of the material, (*c*) dimensional accuracy and stability, (*d*) intricacy of the design, (*e*) required finish, (*f*) cost and life of the casting dies. In nearly all of these, considerable advances have been made in recent months, and it is the present object to outline some of the developments sponsored by New Jersey Zinc Co., following intensive work in its research laboratories.

Dies — Discovery of new zinc die-casting alloys and developments in the art of die design have greatly improved the product by insuring a denser structure. This means less porosity both at the surface and internally. Castings weighing up to 20 lb. have been made; others having walls as thin as 0.015 in. have appeared. Greater intricacy in both design and coring are included in this advance.

Die life varies with the temperatures used; tin and lead-base alloys give no trouble, melting as they do at 400 to 500° F.; zinc alloys are also readily handled at 725 to 850° F. Aluminum alloys are more difficult, melting at 1350 to 1500° F., while copper and brass have a melting point so high that the dies break down rapidly, and so far have not been widely adopted, requiring a highly specialized technique.

While dies of ordinary carbon steel will suffice in many cases, others require alloy steels (chrome-vanadium is a favorite) carefully heat treated. Temperature of operation and number of pieces desired are factors determining the choice. Pressures have ranged around 400 lb. per sq.in. in the pneumatic machines; 1600 lb. per sq.in. is common in machines using plungers. Such high pressures on the metal require

much higher compression to hold the parting surfaces together so that none of the molten metal will squirt through and form fins. This compression has been obtained in modern machines through the use of hydraulic cylinders, cams, and toggles. In one or two instances the latter methods have also been employed to develop metal pressures, but these are more or less isolated cases.

Recent developments in die design have made it possible to manufacture short runs of medium and small-sized castings economically. In this "unit die" system a large block contains the sprue and gates for four cavities, and is so constructed that four separate dies can be slipped into place for as many individual units. This cuts down the amount of steel required for a single die and as many different dies as can be made with standard exterior dimensions can be used with the same master die.

Die life ranges from 50,000 to 200,000 "shots" with the aluminum-base alloys and up to half a million "shots" with the zinc alloys (when using ordinary pressures). There are, of course, very high figures from exceptional runs — one die is known that has produced five million zinc die castings.

Strength and Toughness

Most castings made with lead or tin base are used in such a way that only nominal loads are carried, or if a load must be carried (as in bearings) they are strongly backed up by steel or bronze. When sudden shocks must be encountered or definite strengths developed, the aluminum and zinc alloys are available. These have been subjected to a close study by an important committee of the American Society for Testing Materials, and the results of tests made on castings of various current commercial alloys by a variety of cooperating manufacturers indicate that this class of material is quite uniform and worthy to be ranked with other "engineering materials." Interesting comparisons between the physical properties of various commercial casting metals are given below. The range of values given in the last line includes the improved as well as older zinc die castings.

	Tensile Strength Lb. per Sq. In.	Elongation in 2 In.	Impact Strength ¼-in. Square Bar
Malleable iron	50,000 to 56,000	12 to 22%	8 to 12 ft-lb.
Sand-cast brass	25,000 to 35,000	10 to 23%	up to 20
Grey iron	20,000 to 30,000	–	up to 2
Aluminum die castings	25,000 to 35,000	1 to 5%	2 to 5
Zinc die castings	30,000 to 50,000	1 to 10%	4 to 20

Improved Zinc Alloys — An alloy showing very good properties contains about 3% copper, 4% aluminum, 0.10% magnesium and a minimum of other impurities. It is the basis of the A.S.T.M. specification B 86-31 T adopted as tentative standard in 1931.

The extensive research work done in developing this alloy indicated that a minute quantity of some of the common metals, occurring as impurities in the raw materials or carelessly picked up during the process, exerted a wholly disproportionate effect on the resulting properties of the zinc die castings. Consequently, several producers have put on the market zinc of exceptional purity. The New Jersey Zinc Co., in addition to producing in quantity a brand known as "Horse Head Special" (99.99+% Zn), has developed with it a new series of die casting alloys known as "Zamak No. 3, No. 5 and No. 6," which have materially better properties than the best ones studied by the A.S.T.M. Committee. The tensile strength as cast is about the same, ranging from 35,000 to 50,000 lb. per sq.in., but the elongation in 2 in. is 4 to 10%, and the impact strength attains the remarkable values of 15 to 20 ft-lb. for ¼-in. square bars.

Other properties of the die cast alloys are contained in the table alongside. "Relative fluidity" represents the time for equal volumes to flow through

AVERAGE PROPERTIES OF IMPROVED ZINC ALLOYS, 6 MONTHS OLD

	No. 2	No. 3	No. 5	No. 6
Chemical composition				
Aluminum	4.10	4.10	4.10	4.10
Copper	2.70	–	1.00	1.25
Magnesium	0.03	0.04	0.03	–
Balance Horse Head "Special" [99.99+%] Zinc				
Tensile strength, lb. per sq. in.	47,300	36,100	41,600	39,600
Charpy impact strength, ¼ x ¼ in. bar	15.00	18.25	17.75	18.50
Elongation in 2 in.	8.4%	4.7%	4.2%	10.6%
Compressive strength, lb. per sq. in.	93,100	60,500	87,300	91,700
Shearing strength, lb. per sq. in.	45,800	30,900	38,400	38,000
Modulus of rupture, lb. per sq. in.	116,000	94,700	105,200	102,800
Brinell hardness	83	62	73	71
Specific gravity	6.754	6.644	6.675	6.717
Solidification shrinkage, in. per ft.	0.149	0.138	0.138	0.156
Relative fluidity, sec.	88	60	67	70

a standard orifice at constant temperature. Melting points are all close to 730° F. The alloys are patented, and may be purchased by die casters in pig form or manufactured under license.

Stability of Alloys

One of the advantages of using proper alloys based on zinc of highest purity is that it avoids most if not all of the trouble formerly encountered with change in dimension, warping and disintegration of zinc die castings, either poorly made or exposed to hot, moist atmospheres.

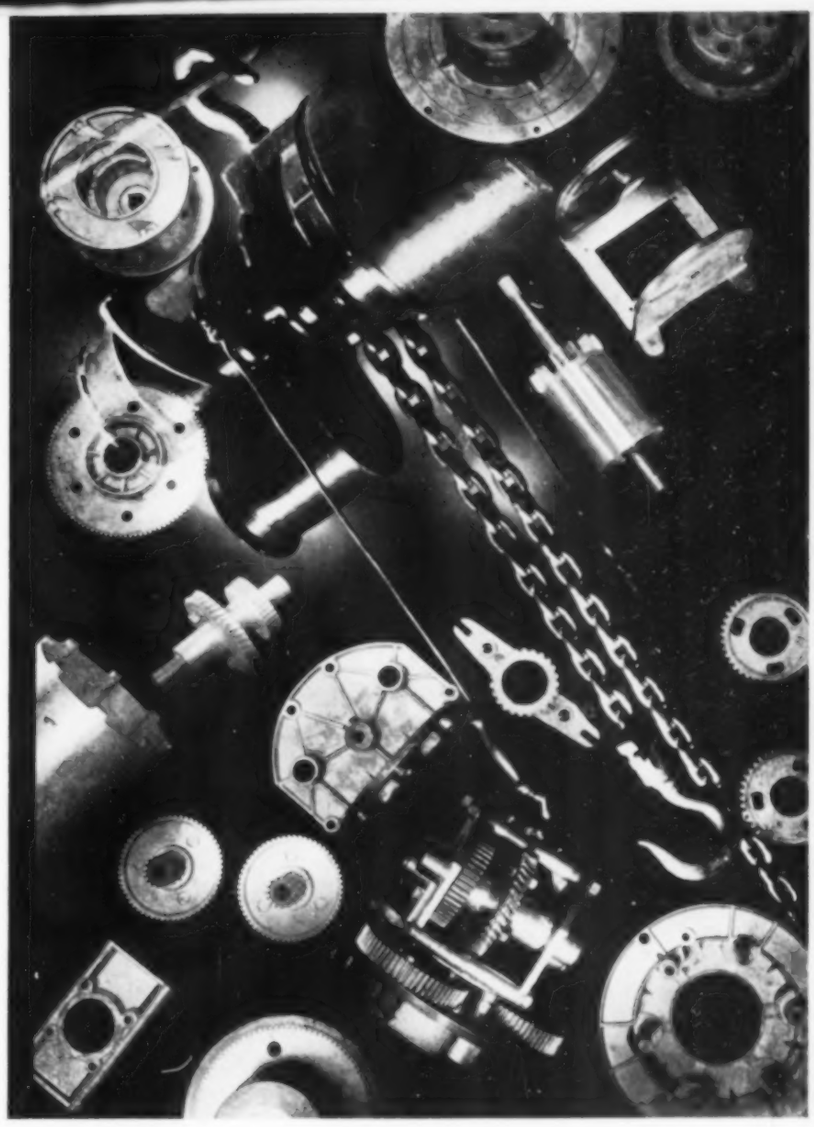
Parts made from these new alloys undergo small decreases in dimensions, impact strength, and hardness shortly after they have been cast. These changes occur in two stages. The first, which is probably due to the relief of strain developed during casting, runs its course in the first four or five weeks after casting. The second stage is probably due almost entirely to phase changes in the micro-constituents, and is much slower than the first. This second change does not occur with alloy No. 3, free of copper.

While such slight changes in dimensions during aging are negligible with most die-cast items, there are some that require close and unchanging tolerances, clearances, or delicate alignments. Wherever absolute dimensional stability is necessary, alloy No. 3 may be used. As stated, this alloy is not subject to any phase change. While small changes occur immediately after they have been cast, if the parts are to be machined or fitted immediately they can be successfully stabilized (that is, the first change can be terminated within a few hours) by either of the following heat treatments:

(*a*) Heat to 158° F. and hold for 10 hr., or to 185° F. and hold for 5 hr., or to 212° F. and hold for 3 hr. At the termination of the heating, the gas burners are turned off and the work is allowed to cool in the furnace over a period of at least 5 hr. to room temperature.

(*b*) Heat to 158° F. and hold for 12 hr., or to 185° F. and hold for 8½ hr., or to 212° F. and hold for 6 hr. The work is then removed from the furnace and air cooled.

These treatments result in a shrinkage on the order of 0.0005 in. per in.



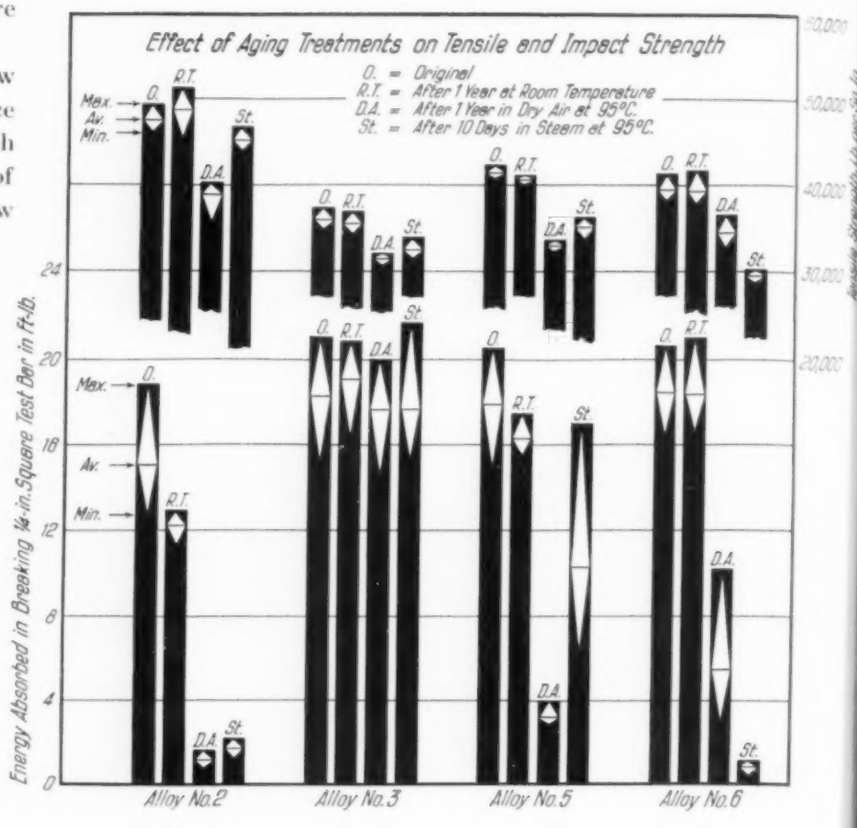
An Example of the Engineering Uses. Three-quarters of the weight of a newly designed 1-ton hoist is zinc die castings

To reiterate, heat treating is unnecessary when the machining or fitting operation is delayed five weeks or more after casting, nor is it required in any event unless absolute stability of dimension is required.

Resistance to Moist Atmospheres — The steam test has been applied to thousands of die cast products by The New Jersey Zinc Co. laboratory and the results studied. This test exposes the articles to a steamy atmosphere at 203° F. It is essentially a drastic corrosion test, as it corrodes the surface of most metals and alloys. In the early days of the die casting industry this test was of considerable value in detecting the sensitivity of the alloys then in use to intercrystalline oxidation. Exposures of 10 days or less were capable of producing this type of attack. It is now generally agreed that this test has no relation to the service to be expected from an alloy (except under the rare case of

identical steam and temperature conditions).

Consequently this test is now employed to detect the presence of contaminating elements which would impair the usefulness of the zinc alloys, and not to show the condition of a die casting after years of service. Dry annealing at 203° F. is a much better method of rapidly determining the extent of slight aging changes, so as to judge whether it will be objectionable for definite uses. Even this is not a reliable measure of the life which may be expected in severe services. The diagram on this page shows that the new alloys maintain their tensile strength quite well even when exposed to the dry annealing or the wet steam test. Alloy No. 3 is unique in that such severe accelerated tests do not impair the impact strength of the samples in the least.


Effect of Aging Treatments on Tensile and Impact Strength
O. = Original
R.T. = After 1 Year at Room Temperature
D.A. = After 1 Year in Dry Air at 95°C.
St. = After 10 Days in Steam at 95°C.
Energy Absorbed in Breaking ½-in.-Square Test Bar in Ft-Lb.
Max.
Av.
Min.
Alloy No. 2
Alloy No. 3
Alloy No. 5
Alloy No. 6

Machining presents no difficulties, although it is seldom necessary because the castings come from the dies, sharp, smooth, and true to design. Sometimes it is cheaper to cut a thread than to make a complicated core or to provide inserts.

Both soldering and welding are possible but difficult. Nickel plating makes a good base for solder, but inserts are suggested as substitutes for both soldering and welding. Scrap castings must not be remelted with virgin metal if lead-tin solders are being used in the plant, as the alloys lose their desirable properties when contaminated with traces of these metals.

Owing to the excellent physical characteristics and the practical elimination of machining of the zinc-base alloys, many parts that were formerly made from steel, brass, and iron (gray and malleable) are now cast with one of these new alloys. The field of die castings is greatly widened through the employment of inserts, thus taking advantage of the particular properties of many other materials at the correct points. Forgings, stampings, screw-machine parts, or molded products of metals, wood fiber, pressed paper and ceramic materials are being used as inserts to perform special duty. Such inserts often eliminate assembling operations and simplify the part. They are held tightly in place by the shrinkage of the metal.

Decorative Finishes — A wide range of commercial finishes may be put on zinc die castings, such as lacquer, enamel, and electroplates. Gold, silver, brass, nickel, and chromium are all effectively used for inside exposures. Chromium plating for outdoor exposure should have a nickel base at least 0.0003 in. thick (0.22 oz. per sq.ft.) overlaid with 0.00002 in. of chromium. Castings come from the dies so smooth that all that is necessary to prepare them for electroplating is a light buffing operation. When lacquer or enamel is to be applied, a slight roughening by chemical or mechanical means is advantageous.

When all these desirable properties of zinc castings are considered, together with recent developments in dies and die casting machines, the field for further applications of these alloys seems wide and attractive.

CORRESPONDENCE AND FOREIGN LETTERS

PARIS, FRANCE — Metallography (that is, knowledge about metals and alloys) has advanced enormously owing to the use of the microscope and the methods of thermo-physical analysis. Its first achievement was a study of the internal architecture, visible with the microscope; it was apparent that alloys were formed by collected particles of one or several constituents, solid solutions of metals, or definite compounds of elements. This interesting information was not at first applied in a "practical" way. Yet as the properties of a building depend, on one hand, on the nature and the properties of the building materials, and (on the other hand) on the shape, the dimensions and the assemblage of these materials, so the properties of alloys depend not only on the chemical analysis — that is, the nature, concentration, and proportion of the constituents — but also on the structure (the fineness, shape, and distribution of particles or essential elements).

General Rules for Formulating Specific Alloys

We have now advanced in metallography to the point where, by a judicious use of such factors as chemical analysis and structure of metals, we can formulate new alloys for special purposes or desired properties. We have learned how the constitution and the structure will be influenced by the transformations of the elementary chemical analysis and also by the thermal and mechanical treatments. To guide our researches and to find the alloying modifications to be used, metallographic science already gives us some precious indications. For instance, the following practices will generally obtain the qualities noted:

1. Malleability may be had from solid solutions, akin to pure metals. Classic examples are brass and gold-silver alloys.

2. High hardness may be sought for among the definite chemical compounds such as cementite in white cast iron, aluminum nitride, titanium silicide and boride, and tungsten carbide. It is then generally associated with great brittleness.

3. Highest electric and thermal conductivities are reached only by pure metals (for example, copper, silver, and aluminum).

4. On the contrary, high electric resistance (as well as constancy of resistivity with varying temperature) must be sought for in the highest concentrated solid solutions such as the iron-nickels and cupro-nickels.

5. Machinability is at its best with alloys having two or more constituents, one of them being unctuous, brittle, or friable, such as graphite, lead, or metallic sulphides.

6. Resistance to friction will be obtained either with a very high general hardness (for example, nitrided steels), *(Cont. on page 52)*

Satisfactory and Early Experiences With High Alloys

BOSTON, MASS. — Mr. Cochran's paper on "Design of Heat Resisting Castings" read before the Buffalo Convention is worthy of compliment for presenting information on a subject about which too much cannot be known. From my experience with General Alloys Co., I feel, however, that there are two points in the version of it published in the October issue of METAL PROGRESS which should be clarified and amplified. The abstract which appeared states, "Although suitable heat resisting alloys were known some years previously it was not until 1928 that anyone would use it for structural purposes or mechanical parts." The intent of the paper is to the effect that it was not until 1928 that alloys were considered sufficiently reliable to be used in *mechanisms* for high temperature operations, such as walking beam furnaces. This is clearly the intent of the paper as read at Buffalo, but the abstract does not convey the same idea.

A great many tons of alloys were used prior to that time, but not walking beams, and I think it should be definitely kept in mind that it was only in 1928 that past experience made it safe and sensible to use these materials in the more complicated mechanism of the walking beam furnace.

Another point in the paper is the statement that "the use of the 35 nickel 15 chromium alloy is indicated only in special cases." I believe that this is absolutely correct in respect to the walking beam furnace. I do not believe it is correct in respect to the more general applications in heat treating furnaces, as by far the large majority of mechanized furnaces installed prior to and since 1928 for normal heat treating operations have developed their reputation for reliability and economy upon the performance of alloys of the 35-15 type.

The comments on design are worthy of particular praise. Much misinformation and much harm has been done to this rapidly growing industry by improper use of structural formulas in developing mechanisms and estimating their load-carrying capacities. This paper certainly should clear the air very materially in this regard.

Mr. Cochran is also to be complimented in emphasizing the necessity and the desirability of taking the producer of the material into the confidence of the designer when working out such problems as the latter may have to solve.

G. C. MCCORMICK

Impact Tests in Specifications for Soft Steels

TURIN, ITALY — A great technical improvement has been made during the last few years by the Italian State Railways. Results have been excellent in all respects. Even a casual traveler can notice them by simply comparing the visible conditions of traffic, and the comfort, speed, and regularity of the present service with those existing a few years ago. These improvements have partly been due to the attention paid by the railways' technical bureaus to the construction of new rolling stock. New and greatly improved designs were adopted, with new and stricter specifications for all the materials of construction, especially metals.

In this last respect very interesting discussions concerning new specifications for metals and alloys have taken place between the railways' technicians and the staffs of various industrial concerns. Satisfactory agreements were reached with no great difficulty on all points except one. This much-discussed point concerned the introduction of the impact test on notched bars into the standard specifications, not only for special or heat treated steels, but also for all ordinary untreated carbon steels, cast, rolled, or forged.

The manufacturers maintained that the impact test depends upon too many fortuitous or unknown factors to be used as a standard method for characterizing the real quality of ordinary untreated carbon steels, manufactured in large tonnages by regular processes and with normal care. They claimed that an effective control of the impact resistance of those steels would entail considerable and expensive modifications of the manufacturing processes, and increased technical supervision — both inconsistent with the low prices the railways were prepared to pay for those products.

Against these statements, the railway engineers alleged the fact that, out of an enormous number of impact tests they had made on materials supplied by all vendors during the last few years, only very few had given results lower than those they would accept under the proposed standard specifications.

As a consequence of these divergent points of view, numerous extensive and complete experimental researches were made on both sides, with the result (somewhat uncommon in similar controversies) that a basis for an agreement was finally found.

In fact, the railway administration has accepted rather low impact figures. Railroad men are not satisfied that the stated figures are sufficient, but they represent the first step which must be taken in this direction. It results that the impact test on notched bars has been introduced, for the first time in Europe, in standard specifications for ordinary untreated carbon steels for railway construction.

The conditions of the test (especially the type of notched bars) were thoroughly studied. Finally the Mesnager bar, 10x10x55 mm., was adopted. An enormous number of experiments were made, both in the laboratories of the State Railways and by steel works, comparing the results obtained for a uniform lot of material when using the original Mesnager notch (2 mm. deep with 1 mm. radius) and the deeper notch (3 mm. deep with same radius, favored in Germany by the "Verein deutscher Eisenhüttenleute" and the "Deutscher Verband für die Materialprüfungen der Technik").

It would require too much space to summarize the mass of experimental material thus gathered, but it may be interesting to mention that, although for certain materials the deeper notch seems to give more reliable and uniform results, for other materials the 2-mm. notch seems to be preferable. The fact was also established that for many qualities of ordinary carbon untreated steels there is no constant or regular ratio between the results obtained with the two different notches. The differences are sometimes very great, and do not seem to vary according to any law.

It is evidently important to reach an international agreement on a standard size notch for impact bars, if test results obtained in different countries are to be compared. The necessity of such a coordination was felt particularly keenly during the discussions mentioned above, because the only way of fixing the practical applications of the impact test in the various specifications for metals is the study and coordination of the largest possible number of experimental results, obtained for the greatest number of similar materials.

FEDERICO GIOLITTI

Numbering Code for Alloy Steel Used in Germany

SCHWEINFURT, GERMANY — German producers and consumers of metals long ago recognized the need of definite regulations governing the ordering, testing, and marketing of materials. As in other countries, many specifications are in existence, but the German Standards Committee, Berlin NW 7, is the center of national standardization. Its members comprise those engaged in the production, sale, and consumption of materials, as well as scientists and institutional representatives. Work is continually in process on the standards, and when issued in final form by the chairman of the Committee, they bear the mark DIN (Deutsche Industrie-Normen).

New pages are continually being prepared and others which are inaccurate or incomplete are open to revision and correction. These last are of value in practical use but possess no final approval. Altogether they represent a comprehensive classification extending through the whole technical field.

The standards collected together in "DIN Handbook No. 1, Standards for Steel, Iron, and Non-Ferrous Metals," are of most importance to producers and consumers of German semi- or full-finished metal products.

Besides classifying metals according to their composition and properties, Handbook No. 1 also contains instructions as to testing, and tables showing standard shapes of rolled or drawn products, as well as official abbreviations for metals and alloys. This forms the subject of this letter.

We in Germany have a definite system of marking, as does the American automobile in-

dustry, but ours is somewhat more comprehensive and more flexible. Moreover, we are inclined to specify finished physical properties rather than the original chemical composition. Advantage is also taken of the fact that all DIN pages relating to steel, for instance, are numbered from 1600 to 1699. Thus, the essential data on screw stock are recorded on DIN 1613, and any order noting the last two significant figures "13" means that the provisions of this sheet must be complied with.

In accordance with these principles "St 34.13" is translated thus: (St) means steel; (34) calls for a minimum tensile strength of 34 kg./sq.mm.; (13) refers to DIN 1613, rolled screw stock. St 00.11 has no tensile properties specified, but is a machine steel (DIN 1611) which must bend either hot or cold to a right angle around a pin four times the thickness of the sample.

Another instance: "St C 35.61" is steel (St) with 0.35% carbon (C 35); otherwise according to DIN 1661 plain carbon steel, forged or rolled, of quality suitable for heat treating.

Nickel and nickel-chromium steel are specified as DIN 1662. *(Continued on page 58)*

LONDON, ENGLAND — The problem of producing and testing steels and alloys intended for use at high temperatures has received much attention both in this country and in Germany in recent years. Steel makers have produced heat resisting steels which retain a high measure of strength even at temperatures as high as 700 to 800° C. (1400° F.) and which at the same time resist scaling or oxidation very successfully. Certain alloys of nickel and chromium with other elements (notably iron, silicon, tungsten and carbon) have also been developed, at all events on the laboratory scale, which appear to possess strength properties at high temperatures even better than those of the best heat resisting steels. Some of these were described in a paper by the present writer and Dr. C. H. M. Jenkin, presented to the Iron & Steel Institute.

Creep Tests Require Long and Precise Observations

That paper, it may be mentioned in passing, was presented to the Iron & Steel Institute although the alloys in question consisted mainly of elements other than iron. The iron content is of the order of 33%, but the high temperatures required for the melting of these alloys resemble those employed in steel making practice, so that they would have to be produced on steel making lines rather than on those ordinarily adopted for non-ferrous materials. Such special steels and alloys, of course, owing to their high content of the expensive elements, nickel and chromium, are unavoidably costly and their use can only be contemplated where very special conditions of service have to be met and the quantities required are not large or their replacement is prohibitive.

On the other hand, there have also been advances in the development of more ordinary types of steel not intended for use at such extreme temperatures but capable of withstanding the more modest range of say up to 400° C. (750° F.), which is coming to be considered practical for superheated steam, and it is here that the problem of how to test the high temperature properties of such steels arises most acutely.

An engineer quite naturally desires or even demands a test which can be made in a few hours at most and some metallurgists have sought to find a way of meeting this demand. Whether or not they have been successful is still a matter of opinion; in the writer's view no truly reliable short-time method of testing the high temperature creep resistance of steels has yet been established.

It is probably generally admitted that the most satisfactory way of ascertaining the resistance to stress at high temperatures (or, as it is generally called, estimating the "limiting creep stress" at a given temperature) consists in subjecting test pieces to continued stresses of various intensities while they are maintained at the temperature in question for a very long time — a time which may, in some cases, need to be extended over several months. In this way, provided that the greatest precautions are taken to ensure steadiness of temperature and the very accurate measurement of stretch or creep, it is possible to obtain a time-creep graph for each intensity of stress which shows whether creep under stress ceases *(Continued on p. 53)*

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FORMULATING SPECIFIC ALLOYS

(Continued from page 47) or with a hard constituent placed in relief, leaving an oily film upon the rest of the surface (for example, babbitt and anti-friction alloys).

7. Chemical resistance or resistance to corrosion by a chemical reagent is obtained, as we have already mentioned in METAL PROGRESS last August, by applying the following rule: "One must try to produce, by adding an element which is passive or auto-protective in the medium in question, a homogeneous solid solution having a rather high concentration."

Of course the problem becomes more complicated when several properties are to be obtained simultaneously and might be solved only by a compromise when the desired properties ask for opposite conditions. Examples would be the production of hard metal which is readily malleable, or a tough alloy readily machinable, or else a strong metal with high electric conductivity. In such difficult cases the nature of the constituents — that is to say, the chemical constitution — must be chosen so as to give *one* of the required properties; those constituents are then assembled as a structural building is constructed, to obtain the other property. Below are some examples:

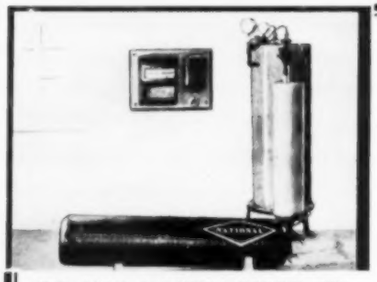
Association of Machinability With Malleability — Machinability is obtained by means of a suitable constituent that is unctuous or friable, for example, graphite, lead, or a sulphide. Precautions must be taken to keep this necessary constituent from decreasing the malleability of the bulk of the alloy by disseminating it in round nodules. Examples are graphite in malleable cast iron, lead in brass, or sulphur in screw machine stock. In practice the desired result may be obtained either by a proper heat treatment (malleable cast iron) or by adding suitable elements. Examples of the latter are manganese and zirconium for the sulphur in steel, or magnesium for the sulphur in nickel and its alloys.

Machinability Combined With High Hardness or Strength — If an alloy must be very strong it must contain no soft or brittle constituent; hard ones, such as those obtained in steels by quenching, are necessary. Machining will then be facilitated by the association of *two* of the strong, hard constituents having slightly different properties. In hardened die blocks or molds for instance, the martensite should be associated with ferrite or troostite or even with non-metallic inclusions.

Strength (or Hardness) Associated With Malleability (or Non-Brittleness) — A very hard constituent, such as a definite compound, will be scattered in a malleable solid solution in particles of optimum fineness and shape. This is well known as the principle of structural hardening, or precipitation hardening by critical dispersion.

It would appear, therefore, that in searching for alloys having definite properties, the investigator has quite a series of indications and rules that may be useful to guide his studies and experiments.

ALBERT PORTEVIN



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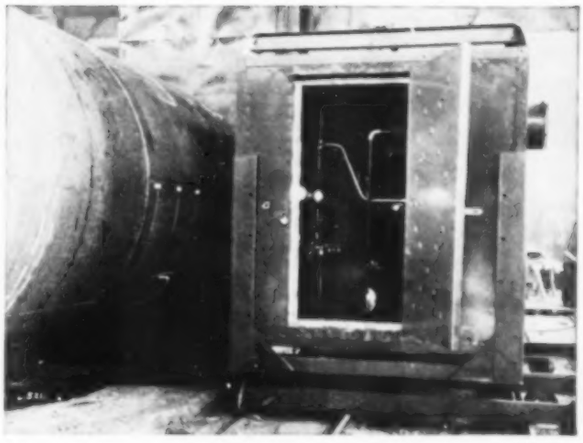
CREEP TESTS

(Continued from p. 50) in the course of time, or whether it tends to continue or even to increase.

Given data of this kind it becomes a matter of judgment for the designer to determine what he regards as safe working stresses under any particular set of conditions. In some instances, for example, all that matters is that the part in question shall not break; a gradual extension of a few thousandths or even hundredths of an inch in the course of years is of no importance. In other cases where small clearances are involved and even more so where the maintenance of an elastic stress in the material over long periods of time is necessary, a much stricter set of conditions has to be imposed in regard to creep. Some engineers in this country go so far as to demand the determination of creep down to a rate of 0.00000001 in. per in. per hr. Even if we set aside these somewhat extreme requirements, the mere question of a safe working load, which shall not lead to rupture in the course of a long period of time, is still difficult to settle.

The more rapid methods which have been proposed generally consist in determining the approximate shape of the time-creep graph over a certain part of its range. Hadfield's "time-yield" method and the methods advocated by the German workers, Pomp, Enders and others, both depend on this principle — the rate of creep at a given temperature and stress being measured over a relatively brief period of time, generally commencing several hours after initial loading. In this way it is suggested that the characteristics of the material at high temperature can be rapidly determined.

It is quite probable that in a great many materials such a method is safely applicable. Where the creep-time graph follows the anticipated course as indicated by the short time observations, satisfactory results can be obtained by these methods. Unfortunately, however, there is in these short time tests no guarantee that the graph will, in the long run, take the anticipated course. It has been found in a number of instances that after the creep-time graph had taken a course in which creep ap-



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IN THE illustration above is shown the twin-tube x-ray unit recently installed by General Electric X-Ray Corporation at the Warren, Pennsylvania, plant of Struthers-Wells Company. By means of its double x-ray tube arrangement, 34 inches of longitudinal seam can be radiographed at each exposure—twice the area ordinarily covered. Many other features, especially as regards adjustment of the apparatus to various sized drums, permit ease of manipulation, flexibility and speed in operation.

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peared to be slowly diminishing as time progressed, the graph at some later stage diverged, creep became much more rapid and rupture ensued! In these cases it is generally found that the fracture is of an intercrystalline character and such failure has been described, perhaps misleadingly, as "intercrystalline cracking."

This phenomenon of intercrystalline rupture at high temperatures is a matter of very serious importance. Some investigators have brushed it aside as being an abnormal phenomenon possibly due to some defect or impurity in the material. With this view the present writer cannot in the least agree. His own early work in conjunction with Ewen and with Humfrey established, on the contrary, that intercrystalline rupture was the normal form of fracture for all metallic materials at sufficiently high temperatures; moreover it was made clear that the temperature at which this type of rupture would ensue depended upon the rate of straining or stretching which was applied to the test piece.

It would take too much space to go into the theoretical explanations of this phenomenon but there is good reason to believe that in any crystalline aggregate the cohesion between the crystals diminishes with rising temperature much more rapidly than the strength of the crystals themselves; this applies not only to the forces resisting actual rupture but also to those which oppose gradual movement or creep. It would seem, therefore, to be very dangerous to assume that the occurrence of intercrystalline rupture is a rare or abnormal phenomenon. It would follow that whether or not under a given stress at a given temperature such ruptures could be developed is really the critical question in regard to the safety of a material at that temperature and under that stress. Unfortunately, this cannot possibly be determined in any rapid manner.

The whole problem is rendered more complicated by the phenomena of recrystallization and grain growth which occur in various metals and alloys at different temperatures when they have been strained. There is also the phenomenon of the softening of a strain-hardened

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crystal by a process sometimes called "crystal recovery" without recrystallization, which even at moderate temperatures may neutralize the normal hardening effect of plastic strain. Beyond this again the chemical effects of the surrounding atmosphere have also to be taken into account. This is not only a question of surface oxidation or scaling but of an action upon the internal cohesion and, perhaps more especially, upon the intercrystalline cohesion of the metal.

In view of these complications it is not surprising and in fact highly desirable that extensive researches on the subject should be continued. This is being actively done in Great Britain both at the National Physical Laboratory, where there is a large battery of creep testing machines, and also at various university and works laboratories, notably at those of Metropolitan Vickers, Ltd., and of Messrs. Thomas Firth & John Brown, Ltd.

At the same time, the practical engineer can derive satisfaction from one important consideration: This is that, after all, materials used for practical work usually belong to certain well-defined types. If, therefore, the behavior of a given type of steel or alloy has been exhaustively studied by research methods, it is probably unnecessary for a similar exhaustive study to be made for each delivery of material of that type. All that can be done, and the writer would suggest all that *need* be done, is to make such tests as will identify, as far as possible, the given batch of material supplied with the type to which it is intended to belong. This can usually be done with sufficient certainty by combining the knowledge of its chemical composition and mode of manufacture with certain relatively simple tests. Possibly, so far as high temperatures are concerned, even a short time test may be sufficient to effect such identification to an adequate extent. Reliance upon such methods, however, can only be justified where there is full knowledge of the properties of that type of material and of the manner in which variations of composition and treatment are likely to affect the results both of short time tests and of the lengthy tests used by research investigators.

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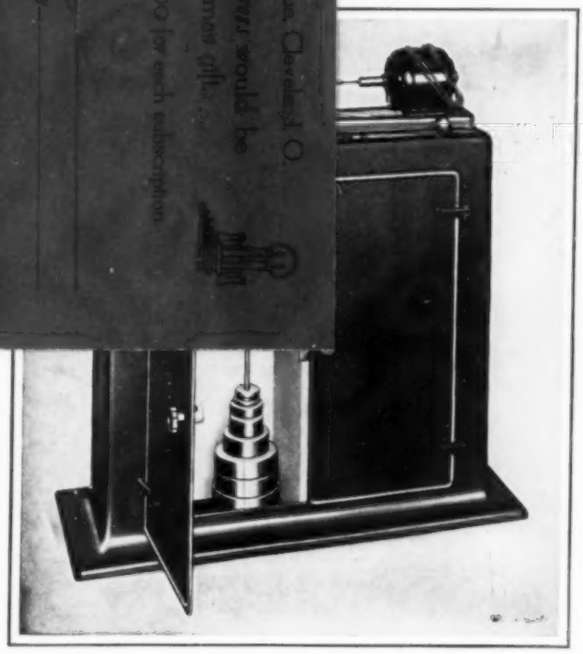

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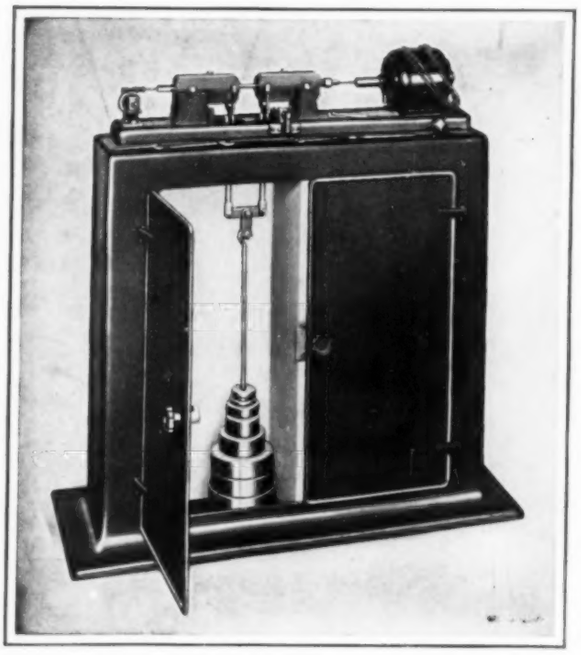

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DIN NUMBERS

(Cont. from p. 50) A number of abbreviations are used here, which may be somewhat confusing. E means carburizing steel (elsewhere means electric steel). V means quenched and tempered. C stands for chromium and N for nickel. Numbers represent the nickel content in tenths of one per cent; w means carbon on the low side of the usual range and h on the high side. Thus "VCN 25w" means a treated (or heat treatable) 2½% Ni-Cr steel with low carbon (0.25 to 0.32% as can be seen by reference to DIN 1662). An E before the DIN number would mean electric steel, B acid bessemer, Th basic bessemer, M open-hearth, T crucible.

The DIN pages referring to steels so far issued are:

1611, Plain carbon machine steel, forged or rolled

1612, Structural shapes, bars and plates

1613, Screw and rivet steel

1620, Sheets; general specifications

1621, Sheets; quality specifications

1629, Seamless tubing

1631, Rails

1632, Steel railroad ties

1661, Heat treatable carbon steels

1662, Nickel and nickel-chromium steels.

DIN 1681 has to do with cast steel (abbreviated as Stg, *Stahlguss*). The capital letter R after a number ("Stg 38.81 R") indicates that it is a steel authorized by the German Railway Commission, the letter S that it is authorized by the German Lloyd, and the letter D has reference to castings with magnetic properties.

DIN 1691 lists approved cast irons (Ge); DIN 1692, malleable iron (Te).

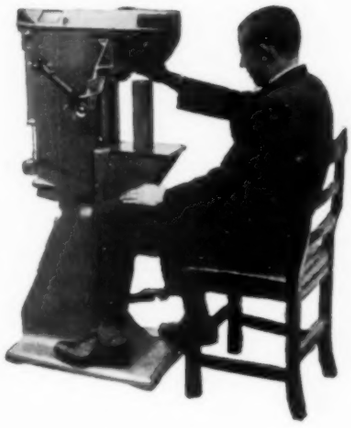
VDE 6400 gives requirements of steels for dynamos and other electrical equipmen[t]. Other VDE numbers cover conductivity wire.

L 11 covers steel tubing for aircraft and L 67 aircraft steel in rod or bar form. L 23, 25, 41, and 42 are aluminum alloys.

The following numbers refer to non-ferrous metals:

DIN 1701, Raw nickel. Abbreviations used for the various forms are: Wüni, squares; Roni, rondelles; Plani, plate; Grani, granulated; Kani, cathode or electrolytic *(Continued on p. 61)*

The VICKERS HARDNESS TESTING MACHINE



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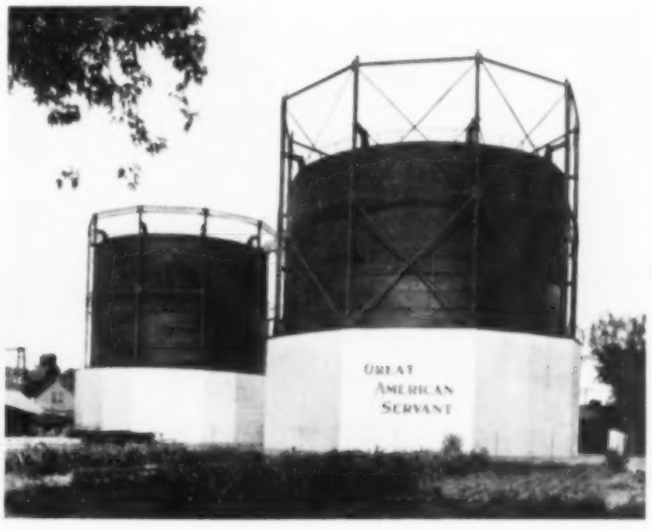

HELPFUL LITERATURE FOR THE ASKING

Heat Treating Forgings—Electric Furnace Co. has issued a reprint illustrating and describing various types of electric and fuel fired furnaces for heat treating forgings. Bulletin D-30.

Liquid Baths—E. F. Houghton & Co. dedicates a valuable 30-page booklet to the subject of the place of liquid baths for heat treating steel, covering temperatures between 350° and 1800° F. Bulletin D-38.

Heating-Unit Design—A unique slide table for calculating instantly the amount of Chromel wire needed for any given heating unit has been put out by Hoskins Mfg. Co. Bulletin D-24.

Cyanides and Salts—Roessler & Hasslacher Chemical Co. has published an 80-page booklet containing valuable data on heat treating steels with cyanides and salts. Bulletin D-29.

Four-Ton Coreless Induction Furnace—Ajax Electrothermic Co. A description of the largest Ajax-Northrup coreless induction furnace now in operation. Illustrated. Bulletin S-41.

Wear and Lubricant Tester—Timken Roller Bearing Co. has prepared a description of a new machine for testing load carrying capacity of lubricants, measuring friction and wear of materials. Bulletin M-71.

Welding Electrodes—Numerous applications of inorganic flux coated welding electrodes are described in a booklet just published by Metal & Thermit Corp. which earlier this year introduced Murex heavy mineral coated electrodes. Bulletin S-64.

Everdur Metal—American Brass Co. has issued a folder describing the application of Everdur as a material for tanks and pressure vessels. Bulletin N-89.

Hy-Ten Alloy Steels—Wheelock, Lovejoy & Co., Inc. "Pertinent Points" folders covering physical properties, heat treatment and applications of all grades of Hy-ten Special Steels. Bulletin D-22.

Machine Heat Treating—American Gas Furnace Co. A 16-page illustrated booklet giving information on the various types of conveyor heating machines available for heat treating on a production basis. Bulletin D-11.

Scleroscopes—Shore Instrument & Mfg. Co. describes its Model D standard recording scleroscope in a recent bulletin which explains the theory and practice of hardness testing with this machine. Bulletin S-33.

Temperature Control—Valuable engineering information on this subject is contained in a well-illustrated 48-page booklet published by Foxboro Co. describing their line of temperature controllers. Bulletin S-21.

Ammonia Dissociators—Ajax Electric Co. has a new bulletin describing the technical and economical advantages of producing hydrogen and nitrogen by dissociating anhydrous ammonia. Bulletin JU-83.

Micro-Metallograph—E. Leitz, Inc. A precision instrument for making accurate photomicrographs without distortion and with absolute flatness of field is described. Bulletin M-47.

Heat and Corrosion Resistant Alloys—General Alloys Co. A new bulletin is available on chrome-nickel and straight chrome heat and corrosion resisting alloys. Bulletin D-17.

Welded Pipe—Republic Steel Corp. has prepared a booklet on its electric weld line pipe and casing. Manufacturing processes and performance data are presented. Bulletin AA-8.

Rust Preventive—A recent publication of Dearborn Chemical Co. describes the well known rust preventive, No-Ox-Id, which is now offered as a paint foundation in the colors red, gray and black. Bulletin JU-36.

Furnace Parts—Driver-Harris Co. has issued a bulletin featuring furnace parts made of their alloys. This bulletin gives data and advantages of Nichrome and Chromax heat resisting alloys in the form of furnace parts. Bulletin N-19.

Deoxidizing Steel—Electro Metallurgical Sales Co. has published a new technical bulletin covering the use of silicon-manganese alloys for deoxidizing steel. Bulletin S-16.

Homo Tempering—A recent publication of Leeds & Northrup Co. describes the Homo method of tempering and the various sizes of Homo furnaces available. Bulletin D-46.

Nickel Steel—International Nickel Co. is publishing a bi-monthly illustrated newspaper devoted exclusively to nickel alloy steels. Contains technical, semi-technical, and news articles dealing with the production, treatment, and uses of these steels as well as other special features. Bulletin JU-45.

Ferro-Carbon Titanium—An illustrated 111-page catalog technically describing this alloy and its use in steel for forgings, steel castings, rail steel, sheets, plates, etc., is offered by Titanium Alloy Mfg. Co. Bulletin J-90.

Refractory Materials—Norton Co. offers a semi-technical booklet giving valuable information on the manufacture, use and application of fused alumina (Alundum), silicon carbide (Crystolon) and fused magnesia refractories products. Bulletin J-88.

Fatigue Testing Machine—Thompson Grinder Co. Interesting data on fatigue testing and description of the rotating beam type of fatigue testing machine are given in Bulletin D-23.

Industrial Application of the X-Ray—General Electric X-Ray Corp. Booklet gives many examples of the use of the X-Ray in the industrial field. Profusely illustrated with radiographs of castings, welds, assemblies, etc. Bulletin D-6.

Metal Progress, 7016 Euclid Ave., Cleveland.

Please have sent to me the following literature as described under "Helpful Literature" in the December issue of METAL PROGRESS. (Please order by number.)

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DIN NUMBERS

(Continued from p. 58) nickel; Uni, remelted nickel. The specification is written "Plani DIN 1701."

DIN 1703, White metal. The specification is written "WM 80 DIN 1703," WM meaning white metal, and 80 the percentage of tin. A letter F following the number (80 F) means that it is lead-free.

DIN 1704, Tin. "Sn 99.75 DIN 1704" represents tin which is 99.75% pure.

DIN 1705, Bronze and red brass. "GBz 10 DIN 1705" represents a cast bronze with 10% tin. WBz indicates rolled bronze, Rg red brass, and Bl-Bz lead-tin bronze.

DIN 1707, Solder. "SnL 50 DIN 1707" represents solder with 50% tin.

DIN 1709, Brass. Ms represents rolled or forged brass, GMs cast brass, So-Ms or So-GMs special brass. "GMs 67 DIN 1709" represents a cast brass with 67% tin.

DIN 1708, Copper. There are five varieties depending on its use, classified as A, B, C, D and E. The specification is written "A-Cu DIN 1708."

DIN 1710, Silver solder. "AgL 4 DIN 1710." The number 4 represents the silver content.

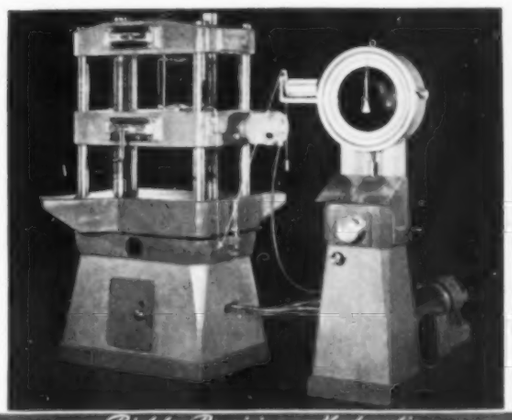
DIN 1711, Hard solder. "MsL 42 DIN 1711." The number 42 represents the copper content.

DIN 1712, Aluminum (pure). "Al 99 DIN 1712" represents a 99% pure aluminum.

It can be seen that this set of specifications is by no means complete. At a congress, held in Berlin in 1927, the problem of classification and designation of the tremendous number of steel and non-ferrous metals, forms and shapes was considered. Work so far accomplished along this line is contained in two looseleaf books, one on non-ferrous metals published by the Deutsche Gesellschaft für Metallkunde, and the other on iron and steel, published by Verein Deutscher Eisenhüttenleute.

Since these books also contain exact information on the testing methods used in Germany, they form a valuable supplement to DIN Handbook No. 1, the specifications so far adopted officially, and are almost indispensible to exporters and importers of metal products.

HANS DIERGARTEN



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IN my dictionary it gives the following definition:

price, *n.* **1.** An equivalent given or asked in exchange; valuation; cost: used also figuratively. **2.** (*archaic*). The quality of possessing value; worth; especially, high value.

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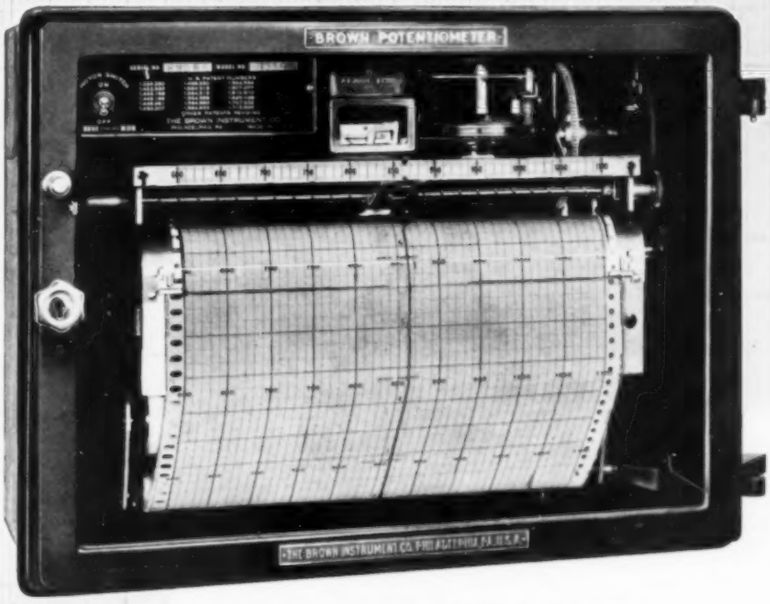

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